SHARP®

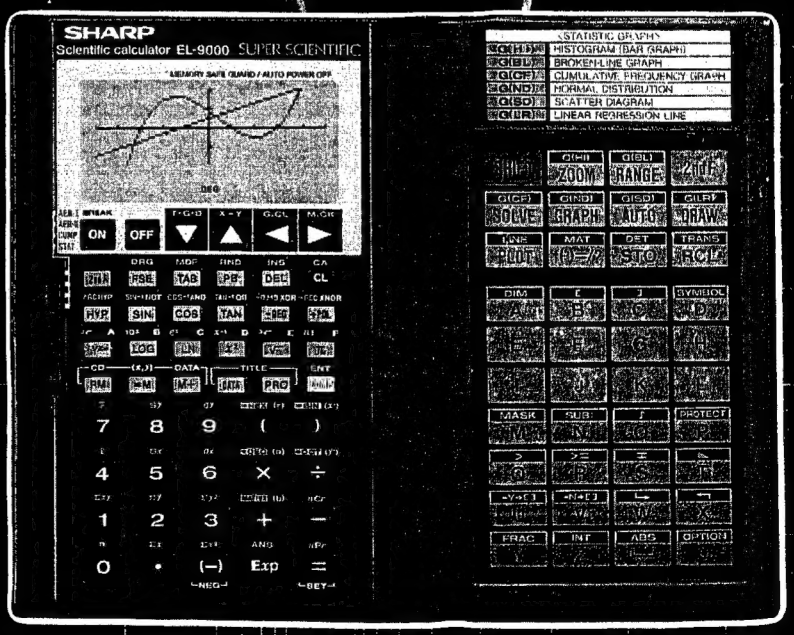
SCIENTIFIC CALCULATOR

SUPER SCIENTIFIC

MODEL

EL-9000

OPERATION MANUAL



NOTICE

- The contents of this manual are subject to change for improvements without notice.

- This calculator is provided with combinations of extremely sophisticated functions and has been shipped after thorough inspections including checks on the operations described in the Manual. Should you encounter any difficulties, contact your nearest SHARP distributor, dealer, or retailer. Your suggestions on the calculator are also invited. However, SHARP is not responsible for any consequences from the use of the calculator.

- SHARP is not responsible for any monetary loss or loss of profits from the use of any of the calculation examples contained in this manual or for any claims from a third party.

- SHARP is not responsible for any loss or alteration of, or damage to, the memory contents as a result of any defect in the calculator or the repair or battery replacement of the calculator.

OPERATIONAL NOTES
(Handling Recommendations)

Because the liquid crystal display (LCD) of the calculator is made of a liquid crystal hermetically sealed between two glass plates, adequate caution must be exercised in handling the calculator.

To ensure the trouble-free operation of the calculator, please observe the following points.

1. Do not fold over the cover containing the right-hand keyboard (i.e., touchboard). This practice may damage the flat cables between the right-hand keyboard and the main circuitry of the calculator.
2. Do not operate any key on the right-hand keyboard with a hard pencil end nor press any key with excessive force. This practice may damage the touchboard or mar its surface.
3. Do not carry the calculator in the back pocket of slacks or trousers.
4. Do not place the calculator in a location subject to direct sunlight, especially in a car with its window closed in hot climate. The calculator may be damaged due to high temperatures.
5. Do not place the calculator in a location exposed to high temperatures (e.g., near a heater). Also avoid locations subject to rapid temperature changes and excessive moisture or dust.
6. Do not drop or bump the calculator.
7. Do not use a cloth moistened with any volatile solvent or water to clean the calculator. Always use a soft, dry cloth.

If service should be required on this unit, use only a SHARP servicing dealer, SHARP approved service facility, or SHARP repair service where available.

- **When a Malfunction Occurs Due to Abnormal Conditions**

  When the calculator is subjected to a large external noise or severe shock while in use, all the keys may become inoperative on rare occasions. Should such an abnormal condition occur in the calculator, take the following steps:

  (1) Set the Mode Selector switch to the COMP position.
  (2) Press the Reset switch, and the display will show the following:

COMP MODE
Ø.

  The calculator can now perform a calculation while retaining its memory contents.

  NOTE: If the memory contents have been changed due to large external noise or severe shock, the memory contents may have already been erased despite the reset operation described in steps (1) and (2) above.

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CHAPTER 1
INTRODUCTION

Introduction

Chapter 1 of this manual introduces you to the SHARP EL-9000 Super Scientific Calculator, a new and powerful computing instrument with graphics capability, by providing you with a basic understanding of the calculator.

The calculator allows direct entry of calculations and expressions (or formulas) as written. As you follow the detailed instructions and calculation examples in Chapters 2, 3, and 5 of the manual, you will find that with this calculator you are not required to learn any machine or computer language, yet the unit provides you with formidable power in mathematical, scientific, engineering, and business calculations.

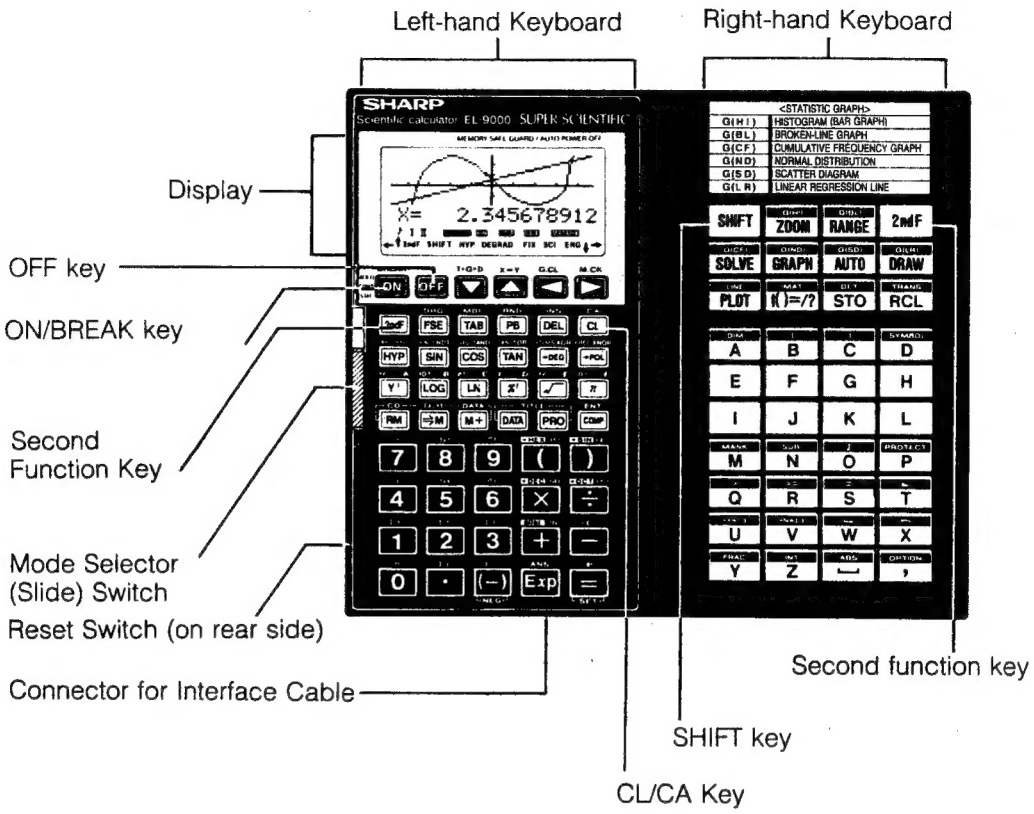
The calculator features such unique functions as algebraic expression reserve function, conditional expression judgment and looping functions, and playback and answer memory functions. These important and useful functions are also detailed in Chapters 2 and 5, together with application examples.

In addition, the calculator allows you to draw various statistical graphs on the screen as well as graphs of intrinsic functions and equations of higher degrees. The calculator's graphics functions are detailed in Chapter 4.

The calculator has optional functions such as SAVE, LOAD, COPY DISP, and PRINT, which are almost comparable to those of pocket computers and are possible when used with optional SHARP CE-50P printer/cassette interface and CE-152 cassette tape recorder. These functions are covered in detail in Chapter 6.

Other items of supplemental information such as operating controls, error conditions, and so forth are included in Appendixes for ready reference.

Names of Components



• Mode Selector Switch

A 4-position slide switch used to select any of the four operation modes of the unit: STAT, COMP, AER-I, and AER-II. (See Operation Modes on page 6 for details.)

• Display

A dot matrix liquid crystal display with each character formed in a pattern of 5×7 dots. The display capacity of the screen is 16 columns by 4 rows for characters and 96 horizontal dots by 32 vertical dots for graphics.

The contrast of the LCD display can be adjusted by continuously pressing the **SHIFT** and [▽] keys for lower contrast and the **SHIFT** and [△] keys for higher contrast.

• Keyboards

The calculator has two keyboards: the left-hand keyboard consisting of 50 keys and the right-hand keyboard, 40 keys. Of the many convenient keys, the five most frequently used keys are briefly introduced here to show you their functions and locations.

ON/BREAK key ..... A key used to turn on the power of the calculator. This key is also used to interrupt the execution of an algebraic expression (i.e., program) in the COMP mode or interrupt the execution of graphic drawing in the COMP or STAT mode.

OFF key ..... A key used to turn off the power of the calculator.

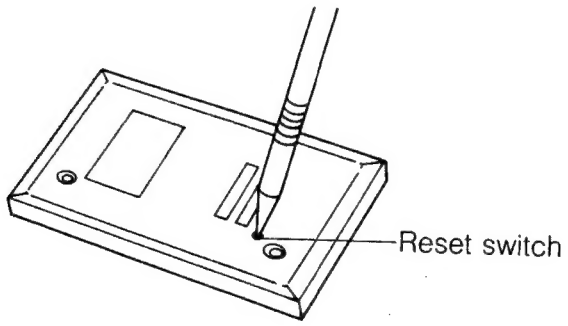
2nd Function keys ..... A function change key provided on each of the left- and right-hand keyboards. Either of the two may be used to designate the second function of another key. The second function of a key is printed in yellow above the key.

CL/CA key ..... A clear/clear all key used to clear the contents of the display, and to release the calculator from an error condition.

• Reset Switch

A switch used to retain or erase memory contents.

NOTE: When pressing the Reset switch, depress the switch with a ball-point pen as shown in the illustration. Avoid use of a sharp-pointed pencil or equivalent with an easy-to-break point.



Key Click Function

This calculator has a key click function which causes each key on both the left- and right-hand keyboards to emit a sound when depressed. This function is convenient for key input confirmation.

The key click mode is set upon pressing the **2ndF** and [♪] keys, causing symbol " ♪ " to appear on the display. Pressing the **2ndF** and [♪] keys for a second time causes the key click mode to reset, causing symbol " ♪ " to disappear.

Auto-Power Off Function

If no key is pressed for about **10** minutes, the power automatically turns off to conserve battery power, but all the memory contents are retained. (The actual time may be shorter or longer than **10** minutes depending upon the operating temperature or battery condition). To resume operation, press the **ON** key.

Operation Modes

The calculator operates in four basic modes: STAT, an abbreviation for STATistical calculation, COMP, an abbreviation for COMPutation, and AER-I and AER-II, abbreviations for Algebraic Expression Reserve. To permit the calculator to operate in any of the four modes, the 4-position Mode Selector switch at the center left side of the left-hand keyboard must be set to the appropriate position as described below.

STAT (bottom)	Places the unit in the STAT mode.
COMP (second from bottom)	Places the unit in the COMP mode.
AER-II (second from top)	Places the unit in the AER-II mode.
AER-I (top)	Places the unit in the AER-I mode.

STAT Mode

The STAT mode allows the calculator to perform single-variable calculations and two-variable statistical calculations including linear regression. In this mode, the calculator can be set in either of the following two submodes; DATA STORE mode which allows storage of each statistical data entered and NON-STORE mode which does not allow storage of such data. (See Chapter 3 for details of operations in the STAT mode.)

In the STAT mode, six kinds of statistical graphs can be drawn on the screen. (See Chapter 4 for details on Graphics.)

COMP Mode

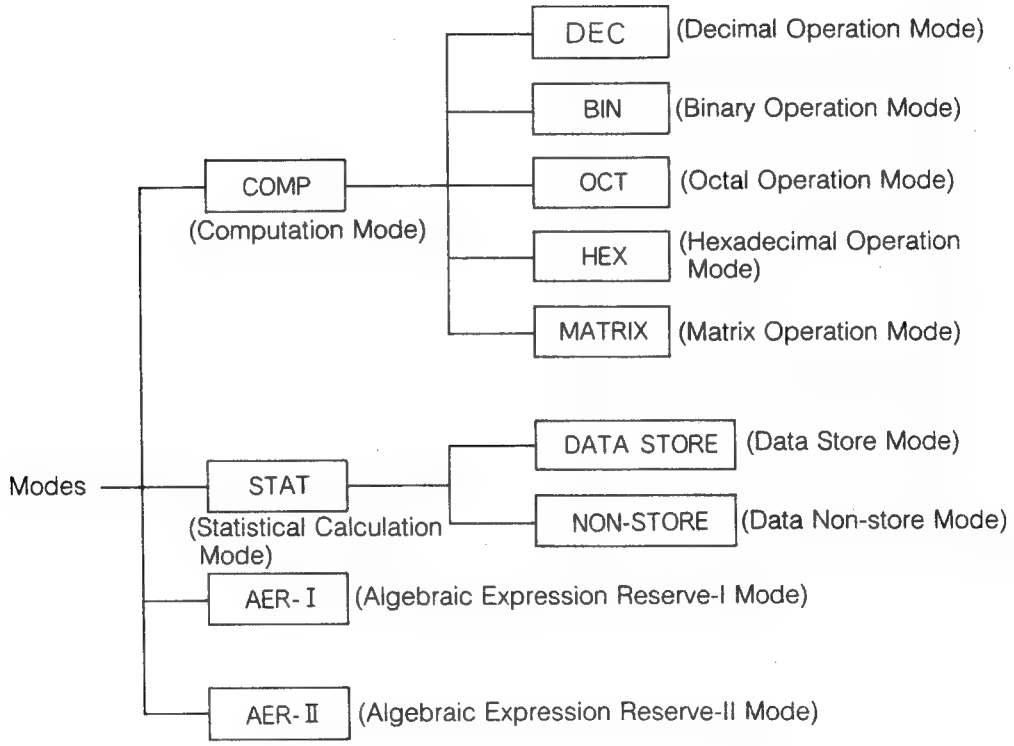
The COMP mode allows the calculator to perform all calculations, except statistical calculations, ranging from the four basic arithmetic functions to algebraic expressions programmed in the AER-I or AER-II mode. In the COMP mode, the calculator normally performs calculations in the decimal number system but can be set in the following submodes to perform special calculations: BIN, OCT, and HEX modes for calculations of binary, octal, and hexadecimal numbers, respectively, plus MATRIX mode for matrix operations.

In the COMP mode (except BIN, OCT, HEX, and MATRIX submodes), graphs of intrinsic functions and other functional equations can be drawn on the screen. (See Chapter 4 for details on graphics.)

AER-I and AER-II Modes

The AER-I mode is a mode to store algebraic expressions using the memories for constants A ~ Z and array variables A[ ] ~ Z[ ] as the variables of the respective expressions. The AER-II mode is a mode to store algebraic expressions using a combination of lowercase letters, special characters, and numbers reduced in size as the variables for the respective expressions, in addition to the memories for constants and array variables. In other words, these programs will be stored in the specified memory for later use in the COMP mode. (See Chapter 5 for details on programming and program execution.)

The relationship of the respective modes is illustrated below.



Fundamentals of Operation

Key Operation

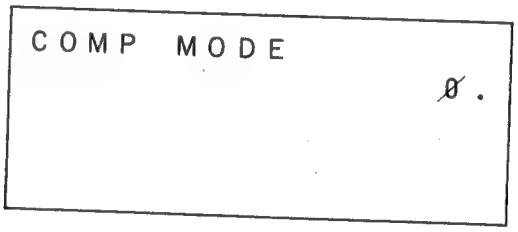
The calculator is provided with a wide variety of functions including scientific, graphics, and algebraic expression reserve functions as well as four basic arithmetic (add, subtract, multiply, and divide) functions. Here, the procedural steps in performing basic calculations are briefly covered to warm you up before going into the details described in later chapters.

(1) Power ON

As mentioned earlier, you will find the **ON** key at the left most side of the left-hand keyboard beneath the LCD display. Simply press this key to power your calculator.

(2) Operation Mode Selection

The calculator operates in four basic modes: STAT, COMP, AER-I, and AER-II. For the purpose of explanation, the unit is put in the COMP mode by setting the Mode Selector switch to the COMP position.



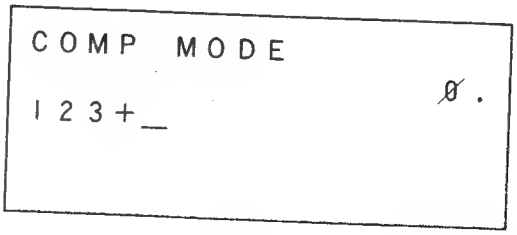
(3) Add, Subtract, Multiply, and Divide Functions

To perform any of the four basic arithmetic functions with this calculator, enter the numeric data and press the algebraic keys (+, −, ×, ÷, =) in the same sequence as you would do with any other scientific calculators.

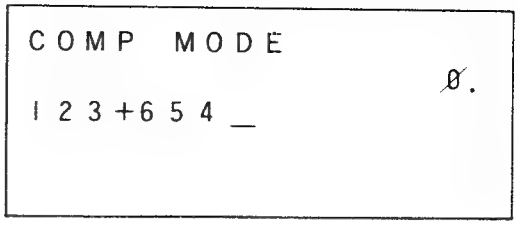
Example 1:

To calculate 123 + 654 =

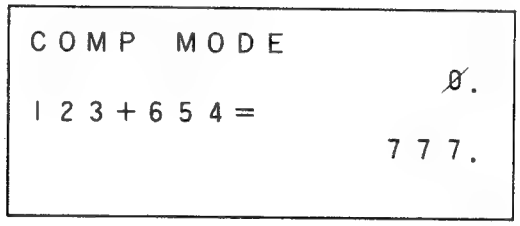
[1] [2] [3] [+]



[6] [5] [4]

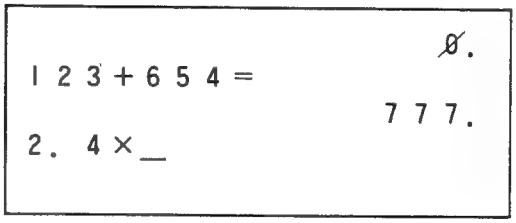


[=]

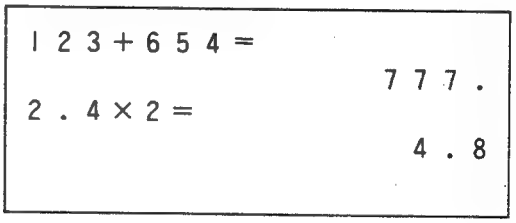


Example 2:
To calculate 2.4 × 2

[2] [·] [4] [×]



[2] [=]



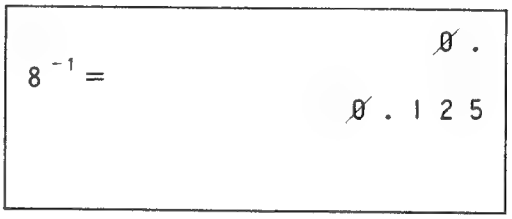
If you make an error in key sequence and an error message appears in the display, press the **CL** key and enter the data again in the correct sequence. If you key in the incorrect data, use the [▷] or [◁] key to move the cursor over to the incorrect number or sign in the display and then enter the correct data. (See APPENDIX D for Error messages.)

(4) Scientific functions
As an example of scientific functions, we will solve for the reciprocal of a number using the Reciprocal (x^{-1}) key.

Example: To solve for 1/8 = (or 8^{-1} =)

Key in:

[CL] [8] [2ndF] [x^{-1}]
[=]



NOTE: x^{-1} is the second function of the [x^2] key and can be activated by pressing the **2ndF** key, then the [x^2] key.

Key Functions

- With the calculator, most of the keys have two functions, whereas some keys have three, and others just one. The function printed on the key itself is caused to occur when you press the key alone. The function printed in yellow above the key is the second function of that key, and becomes effective only when the key is pressed following the function change key labeled "**2ndF**" as you have just done in the above calculation example. The **2ndF** key is located on each of the left- and right-hand keyboards. Depression of either key provides the same function.

- The following functions labeled in silver white or green on the respective keys are effective only in specific modes and are not the second functions. (In other words, you need not press **2ndF** before these keys.)

NOTE: The function labeled "ENT" above the **COMP** key and the functions labeled "NEG" and "SET" below the [(−)] and [=] keys, respectively, are not the second functions of these keys.

(1) Functions labeled "TITLE" in green above **DATA** and **PRO** keys, respectively, are those used for data title search in the MATRIX or COMP mode and program title search in the AER-I or AER-II mode.

(2) Functions labeled "CD, (x, y), and DATA" in silver white color above the **RM**, ⇒ **M** and **M+** keys, respectively, are those used for statistical calculations and are thus effective only in the STAT mode. (See Chapter 3 for statistical calculations.)

(3) Functions labeled "A,B,C,D,E, and F" in silver white color at the right above the **Y^x**, **LOG**, **LN**, [x^2], [$\sqrt{\ }$], and [π] keys, respectively, are those used for entry of hexadecimal numbers in the HEX mode.

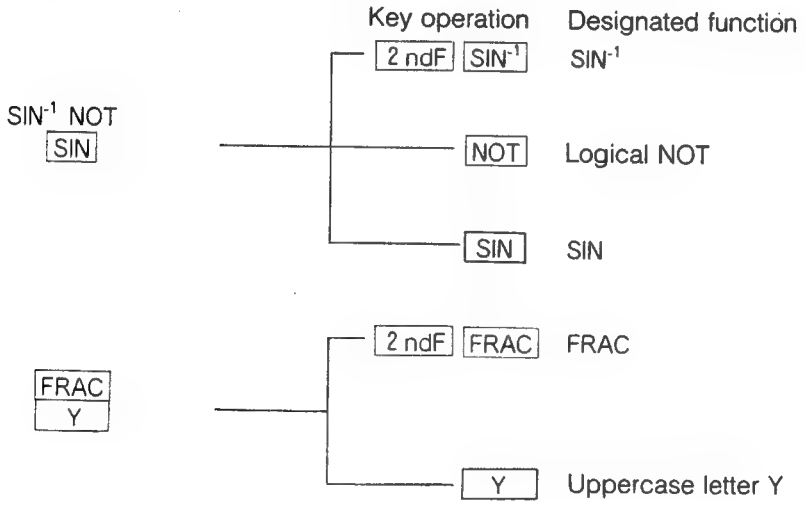
(4) Functions labeled "NOT, AND, OR, XOR, and XNOR" in silver white color at the right above the **SIN**, **COS**, **TAN**, **→DEG** and **→POL** keys, respectively, are those used to perform the logical operations of binary, octal, and hexadecimal numbers in the respective number system modes.

NOTE: Multiply command "×" and upper- and lowercase letters "X" are distinguished from one another by indicating them on the display as follows:

	Key	Display
X (letter)	→ [X]	X (uppercase letter)
		x (lowercase letter)
× (multiply)	→ [×]	×

Conventions for Key Entry Descriptions

• In the following Chapters, key operations and key functions are described whenever possible as shown in the following examples.



• All numeric keys for data entry are not enclosed in a box unlike other boxed keys indicating that they are the keys pressed.

[1] [2] [3] [•] [4] → 1 2 3 . 4 (decimal number)

[2] [B] [C] → 2 BC (hexadecimal number)

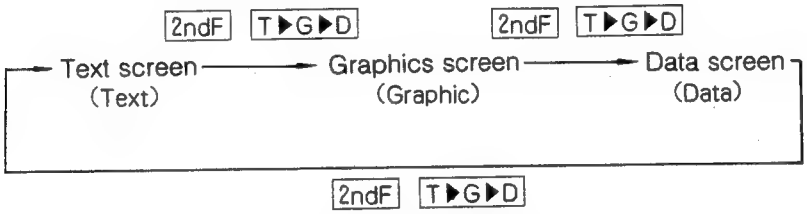
• The word "key in" or "press" before each key operation is omitted when self-explanatory.

Display Screens & Indicators

Display Screens

• Basic display screens

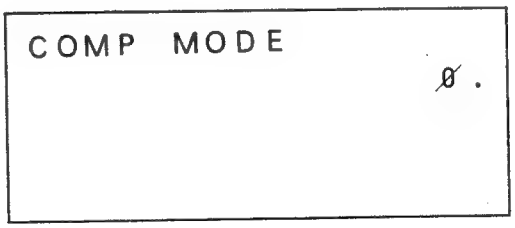
The display screens of the calculator are divided into three basic types: Text, Graphics, and Data screens.
The function of each screen is as follows:
(a) Text screen: Displays algebraic expressions and various commands.
(b) Graphics screen: Displays graphs and coordinate values.
(c) Data screen: Displays statistical data, array variables (matrix data), etc.
These screens are independently stored in memory and selected in rotation at each depression of the Screen Selector (**2ndF, T▶G▶D**) key in the COMP or STAT mode. Keep pressing the selector key until the required screen is selected.



The initial screen of each display screen is as shown below.

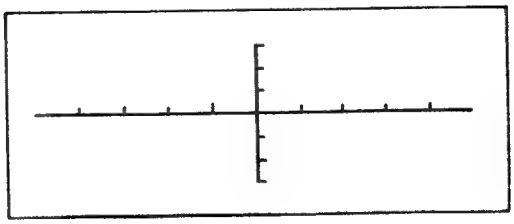
(Set the Mode Selector Switch to the COMP position.)

Text screen



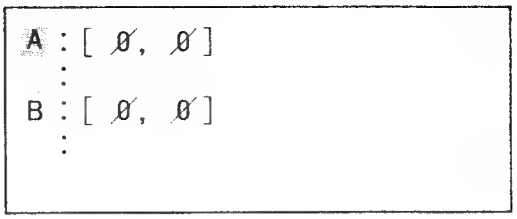
2ndF T▶G▶D

Graphics screen



2ndF T▶G▶D

Data screen



NOTE:
- When switching to any of these basic display screens in the STAT mode, set the DATA STORE or NON-STORE mode before pressing the **2ndF** and **T▶G▶D** keys.
  If any entries have already been made, the initial screens may not be the same as those shown above. To obtain the same initial screens, press the Reset switch and **ENT** key to clear the entries.
- In the BIN, OCT and HEX submodes of the COMP mode, the text screen can be switched to neither the data screen nor the graphics screen, because array variables cannot be defined and graphic functions are ineffective in these submodes. Similarly, in the MATRIX submode, the graphics screen cannot be selected, because graphic functions are ineffective in this submode.

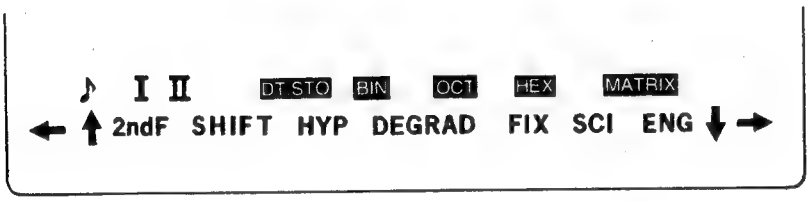
• Special display screens

In addition, the calculator has the following special screens:

(a) Memory check screen: Used to verify the remaining bytes in memory.
(b) Graphic range screen: Used to set the display range of a graph, scale, etc.
(c) Optional command select screen: Used to select commands to an optional printer or cassette tape recorder and commands for data transfer between two EL-9000 units.

Details on the special screens are provided in Chapters 4 and 6, and Appendix C.

Indicators



With this calculator, the following indicators will appear at the bottom part of the LCD screen.

♪ : Indicates that both the keyboards of the calculator are in the key click mode.

I, II: Indicates that the calculator is set in the AER-I or AER-II mode. Also indicates that the program (algebraic expression) stored in the AER-I or AER-II mode is accessed in the COMP mode.

DT.STO: Indicates that the DATA STORE submode has been selected in the STAT mode.

BIN: Indicates that the calculator is in the BIN (binary number system) mode or that the displayed number is a binary number.

OCT: Indicates that the calculator is in the OCT (octal number system) mode or that the displayed number is an octal number.

DISPLAY SCREENS & INDICATORS

HEX: Indicates that the calculator is in the HEX (hexadecimal number system) mode or that the displayed number is a hexadecimal number.

MATRIX: Indicates that the calculator is in the MATRIX (Matrix Operation) mode.

2ndF: Indicates that the second function of another key has been specified.

SHIFT: Indicates that uppercase letters A through Z and numbers 0 through 9 reduced in size are selectable or that the calculator's display is ready for contrast adjustment.

HYP: Indicates that the hyperbolic function has been specified.

DEG: Indicates that "degrees" must be used as the angle of unit for the calculation.

RAD: Indicates that "radians" must be used as the angle of unit for the calculation.

GRAD: Indicates that "grads" must be used as the angle of unit for the calculation.

FIX: Indicates that the result of a calculation is to be displayed in the fixed decimal point system.

SCI: Indicates that the result of a calculation is to be displayed in the scientific notation system.

ENG: Indicates that the result of a calculation is to be displayed in the engineering notation system.

↑, ↓: Indicates that the information that has already been displayed or is yet to be displayed exists above or below the information now on the display.

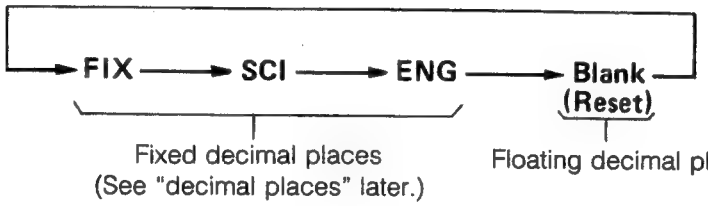
←, →: Indicates that the information that has already been displayed or is yet to be displayed exists on the left or right of the information now on the display. Both the "←" and →" signs appear and flash together with message "COMPUTING", "PRINTING", "SAVING", or "LOADING" while the calculator is performing time-consuming operations such as drawing a complicated graph and, outputting data on the printer or cassette tape recorder, etc.

Display Systems & Decimal Places

Display Systems

The calculator has four different display systems which can be selected with the **FSE** (display mode control) key.

When you press the **FSE** key in the COMP mode, the display mode indicator "FIX", "SCI", or "ENG" or a blank (none of these) will appear at the bottom part of the display.
The **FSE** key is operative only after the result of a calculation has been displayed or when the calculator is cleared with the **CL** key.



The designated decimal point system and decimal places will be retained even when the calculator is turned off.

(1) FIX (FIXed decimal point system)
• Each calculation result is displayed after being rounded to the number of decimal places selected with the **TAB** key.

• When a calculation result is to be used for further calculations or formulas, the contents displayed will be used.

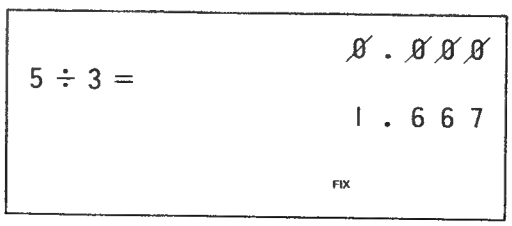
When the absolute value of a calculation result is less than 1, the result may be displayed in the exponential form (scientific notation) according to the number of decimal place selected with the **TAB** key.

Example 1:
If the absolute value of a calculation result is 1 or more

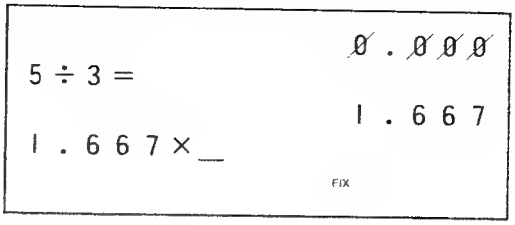
[CL] [FSE] (To display FIX indicator)

[TAB] 3 (To fix the number of decimal places to 3)

5 [÷] 3 [=]

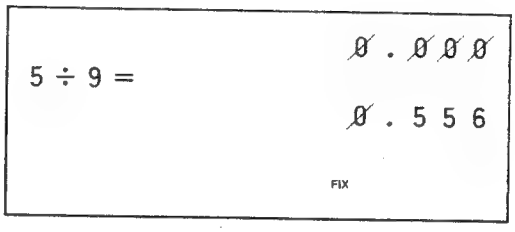


[×]

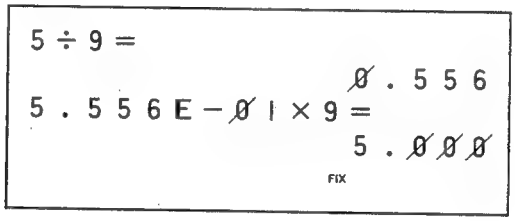


Example 2:
If the absolute value of a calculation result is less than 1

[CL] 5 [÷] 9 [=]



[×] 9 [=]



(2) SCI (SCIentific notation)

- Each calculation result is displayed in the scientific notation system ($A \times 10^B$). Since the mantissa part of the calculation result is displayed in accordance with the decimal place designation (TAB), the number of significant digits can be easily designated. The next digit after the specified number of decimal places is automatically rounded up or off.

- When a calculation result is to be used for further calculations or formulas, the contents displayed will be used.

Example:

[CL] [FSE] (To display SCI indicator)

[TAB] 2 (To fix the number of decimal places to 2)

0.3 [÷] 7 [=]

```
                    Ø . ØØE  ØØ
Ø . 3 ÷ 7 =
                    4 . 29E−Ø2
                          SCI
```

The above display means that the number of significant digits has been fixed to 3.

(3) ENG (ENGineering notation)

● Each calculation result is displayed in the engineering notation system ($A \times 10^B$). Like the scientific notation system, the mantissa part is displayed according to the decimal place designation (TAB), but the exponent part is automatically set to a multiple of 3 (... −6, −3, 0, 3, 6,...) for display. Therefore, any number displayed can be easily read in units of K (kilo-: 10^3) or m (milli-: 10^{-3}), etc., that is commonly used in the engineering field. The next digit after the specified number of decimal places is automatically rounded up or off.

● When a calculation result is to be used for further calculations or formulas, the contents displayed will be used.

Example:

[CL] [FSE] (To display ENG indicator)

[TAB] 2 (To fix the number of decimal places to 2)

0.3 [÷] 7 [=]

```
                    Ø . ØØE  ØØ
Ø . 3 ÷ 7 =
                    42 . 86E−Ø3
                          ENG
```

(4) Blank (i.e., when none of FIX, SCI, and ENG is displayed)

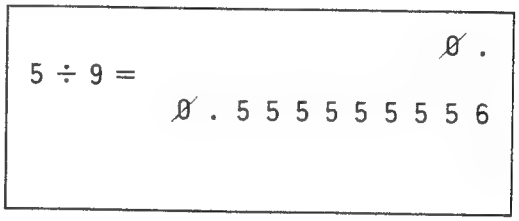
• Each calculation result is displayed in the floating decimal point system. Calculation result x is displayed on the basis of scientific notation if it is outside the range of $0.000000001 \leqq |x| \leqq 9999999999$ or not zero.

• When a calculation result is to be used for further calculations or formulas, the calculator will secure as many significant digits as possible (10 digits max.) for the next formula.

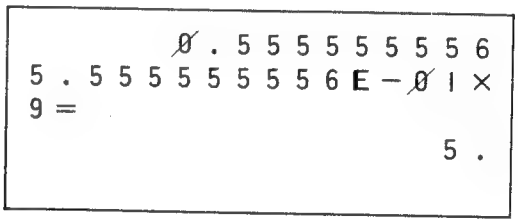
Example:

[CL] [FSE] (To display none of FIX, SCI, and ENG)

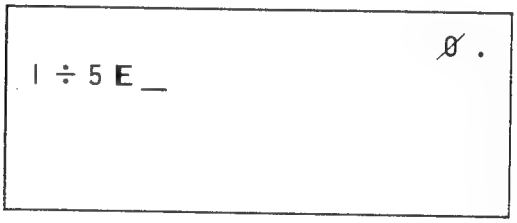
5 [÷] 9 [=]



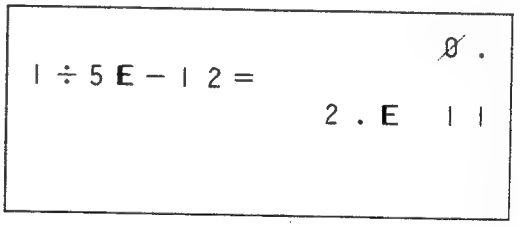
[X] 9 [=]



[CL] 1 [÷] 5 [Exp]



[(−)] 12 [=]



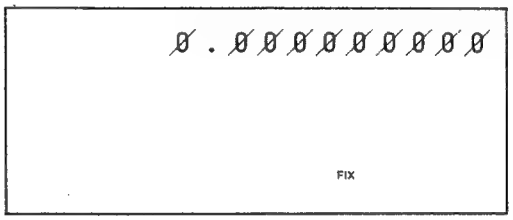
Decimal Places

The **TAB** key is used to specify the number of decimal places in a calculation result when the FIX, SCI, or ENG mode is set. The number of decimal places is specified by the numeral key (**0** ~ **9**) following the **TAB** key. Carry over will be automatically rounded.

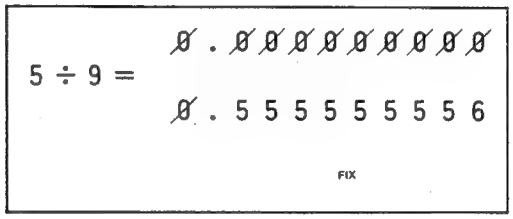
Use the **TAB** key when the calculation result is displayed or when the calculator is cleared with the **CL** key.

[CL] [FSE] (To display FIX indicator)

[TAB] 9 (To fix the number of decimal places to 9)

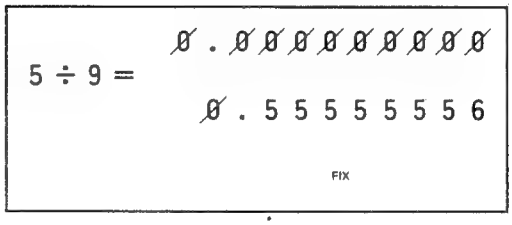


5 [÷] 9 [=]



[TAB] 8

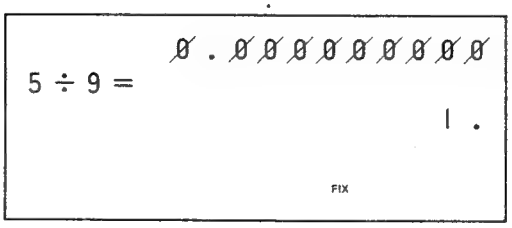
(To fix the number of decimal places to 8)



⋮

[TAB] 0

(To fix the number of decimal places to 0)



NOTE: 1. If a number cannot be displayed in the number of decimal places specified by **TAB**, the number may be displayed in less than the number of decimal places specified by **TAB** (i.e., the integer part is displayed with precedence over the decimal fraction part).

Example: TAB = 3

1 [÷] 3 [Exp] [(−)] 8 =33333333.33

2. The designated number of decimal places is retained even when the display system is changed or when the power is turned off.

CHAPTER 2

OPERATIONS IN COMP MODE

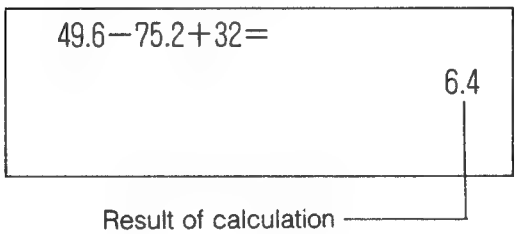
Before operating each calculation example in this chapter, make sure that the Mode Selector switch is in the COMP position and then press the **2ndF** and **CA** keys to clear the calculator.
Unless otherwise stated, all the following calculation examples are to be performed in the floating decimal point system. If any of the **FIX**, **SCI**, and **ENG** indicators is appearing in the display, press the **FSE** key consecutively until none of these indicators appears, indicating that your calculator's display is in the floating decimal point mode.

Addition, Subtraction, Multiplication, & Division

Examples shown here are the mixed calculations of the four basic functions. Because this calculator uses algebraic logic, calculations are not necessarily performed in the order entered. For example, multiplication is carried out before addition.

No.	To solve for	Key in	Your answer
1	49.6−75.2+32=	49.6 [−] 75.2 [+] 32 [=]	6.4
2	45+285÷3=	45 [+] 285 [÷] 3 [=]	140
3	(45+285)÷3=	[(] 45 [+] 285 [)] [÷] 3 [=]	110
4	$\frac{18+6}{15-8}$=	[(] 18 [+] 6 [)] [÷] [(] 15 [−] 8 [)] [=]	3.428571429

NOTE: 1. Your answer is displayed with right justification on the line following the line on which the expression for the calculation has been entered.



2. The parenthesis keys specify which group of numbers to calculate first whenever there is a choice. If you omitted parentheses in Example 3, your answer would be 140 as in Example 2 because division takes precedence over addition. (See APPENDIX E for details on Priority levels.)

No.	To solve for	Key in	Your answer
5	$42\times(-5)+120=$	42 [×] [(−)] 5 [+] 120 [=]	−90
6	$(5\times10^{3})\div(4\times10^{-3})=$	5 [Exp] 3 [÷] 4 [Exp] [(−)] 3 [=]	1250000
7	$72\times(((56+23)\times2)-72\div4)=$	72 [(] [(] [(] 56 [+] 23 [)] [×] 2 [)] [−] 72 [÷] 4 [=]	10080

NOTE: 1. When you enter a negative number as in Example 5, press [(−)] before the negative number.

2. The **Exp** key is used to enter the exponent part of a number.

3. In Example 7,

   (1) The multiply key immediately before the open parenthesis may be omitted.

   (2) The close parenthesis immediately before the [=], ⇒**M**, **M+**, **2ndF M+**, **STO A** ~ **STO Z**, →**HEX**, →**OCT**, →**BIN**, or →**DEC** key may be omitted.

   (3) Plural parentheses may be entered in an expression with other calculation commands for more complicated arithmetic sequences, provided that the number of pending operations in the calculator does not exceed 16 and the number of pending values in the calculator does not exceed 8. (See APPENDIX E for details on Pending operations.)

Scientific Functions

Scientific calculations are performed in the same manner as basic calculations. As you will note in the following examples, scientific functions are entered as you would normally read them.

Trigonometric and Inverse Trigonometric Functions

• When you solve for any of the trigonometric and inverse trigonometric functions, you must first designate the unit of angle applicable to the function by operating the **2ndF** and **DRG** keys. As these two keys are pressed consecutively, the indications "DEG", "RAD", and "GRAD" appear in rotation at the bottom part of the display. Keep pressing **2ndF DRG** until the desired unit of angle is set on the display.

DEG: Degree [°]
RAD: Radian [RAD]
GRAD: Grad [g]
90[°]=π/2 [RAD] = 100 [g]

NOTE: The designated unit of angle will be retained in memory even when the power is turned off. Therefore, you need not redesignate the angular unit each time the power is turned on.

No.	Angular unit	To solve for	Key in	Your answer
1	DEG	SIN63=	SIN 63 =	0.891006524
2	RAD	$\cos\frac{\pi}{4}=$	COS (π ÷ 4) =	0.707106781
3	GRAD	TAN150=	TAN 150 =	−1

NOTE: To solve for the function value of an expression such as in COS π/4 in Example 2, parenthesize the expression.

• The calculation results of the respective inverse trigonometric functions are expressed within the following limits.

$\theta = \mathrm{SIN}^{-1}x$, $\theta = \mathrm{TAN}^{-1}x$

DEG : $-90 \leqq \theta \leqq 90$

RAD : $-\frac{\pi}{2} \leqq \theta \leqq \frac{\pi}{2}$

GRAD : $-100 \leqq \theta \leqq 100$

$\theta = \mathrm{COS}^{-1}x$

DEG : $0 \leqq \theta \leqq 180$

RAD : $0 \leqq \theta \leqq \pi$

GRAD : $0 \leqq \theta \leqq 200$

• In addition to the designation of the unit of angle using the **2ndF** and **DRG** keys, you must use the **2ndF** key for each calculation example here to designate the second function of another key.

No.	Angular unit	To solve for	Key in	Your answer
4	DEG	$SIN^{-1}0.5=$	2ndF SIN^{-1} 0.5 =	30
5	RAD	$COS^{-1}-1=$	2ndF COS^{-1} (–) 1 =	3.141592654
6	GRAD	$TAN^{-1}1=$	2ndF TAN^{-1} 1 =	50

Hyperbolic and Inverse Hyperbolic Functions

When using any of the hyperbolic and inverse hyperbolic functions, the "HYP" indicator will appear at the bottom part of the display.

No.	To solve for	Key in	Your answer
1	SINH4=	HYP SIN 4 =	27.2899172
2	$(COSH1.5+SINH1.5)^2=$	(HYP COS 1.5 + HYP SIN 1.5) x^2 =	20.08553692
3	$SINH^{-1}9=$	2ndF ARCHYP SIN 9 =	2.893443986
4	$TANH^{-1}\frac{5}{7}=$	2ndF ARCHYP TAN (5 ÷ 7) =	0.895879735

Other Scientific Functions

Function		To solve for	Key in	Your answer
Exponential	e^x	$e^3=$	2ndF e^x 3 =	20.08553692
	10^x	$10^{1.7}=$	2ndF 10^x 1.7 =	50.11872336
Logarithmic (Natural & common logarithms)		LN20=	LN 20 =	2.995732274
		LOG50=	LOG 50 =	1.698970004

SCIENTIFIC FUNCTIONS

Function	To solve for	Key in	Your answer
Squaring (x^2)	$5^2-4^2=$	5 [x^2] [−] 4 [x^2] [=]	9
Reciprocal (x^{-1})	$\frac{1}{8}=$	8 [2ndF] [x^{-1}] [=]	0.125
Square root ($\sqrt{\ }$)	$\sqrt{49}+\sqrt{64}=$	[$\sqrt{\ }$] 49 [+] [$\sqrt{\ }$] 64 [=]	15
Cubic root ($\sqrt[3]{\ }$)	$\sqrt[3]{123\times6}=$	[2ndF] [$\sqrt[3]{\ }$] [(] 123 [×] 6 [)] [=]	9.036885658
Power (Y^x)	$3^4=$	3 [Y^x] 4 [=]	81
	$8^{-2}=$ (or $\frac{1}{8^2}=$)	8 [Y^x] [(−)] 2 [=]	0.015625
	$(12^3)^{\frac{1}{4}}=$ (or $\sqrt[4]{12^3}=$)	12 [Y^x] 3 [Y^x] 4 [2ndF] [x^{-1}] [=]	6.447419591
Power root ($\sqrt[x]{\ }$)	$\sqrt[4]{81}=$	4 [2ndF] [$\sqrt[x]{\ }$] 81 [=]	3
Factorial (n!)	$6!=(6\times5\times4\times3\times2\times1=)$	6 [2ndF] [n!] [=]	720
Permutations $nPr=\frac{n!}{(n-r)!}$	${}_{10}P_3=$	10 [2ndF] [nPr] 3 [=]	720
Combinations $nCr=\frac{n!}{r!(n-r)!}$	${}_{10}C_3=$	10 [2ndF] [nCr] 3 [=]	120
Fraction (FRAC)	(58÷8=7+?)	[2ndF] [FRAC] [(] 58 [÷] 8 [)] [=]	0.25
Integer (INT)	(58÷8=?+0.25)	[2ndF] [INT] [(] 58 [÷] 8 [)] [=]	7
Absolute value (ABS)	|LOG0.75|	[2ndF] [ABS] [(] [LOG] .75 [)] [=]	0.124938737

Conversions of Coordinates and Angles

• Coordinates

Two keys are used for conversions of coordinates.

→**POL**: Converts rectangular coordinates (x, y) into polar coordinates (r, θ)

→**REC**: Converts polar coordinates (r,θ)into rectangular coordinates (x, y)

NOTE: Because the calculator uses store memory Z to store the value of θ or y obtained from the conversion of coordinates, the contents of store memory Z will be changed as the result of the conversion. (See Memory calculations on page 41 .)

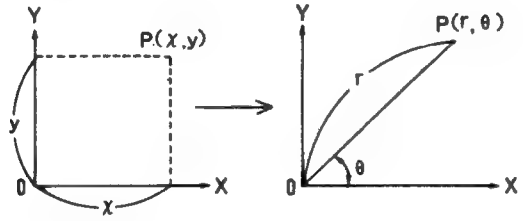
(1) Conversion of rectangular coordinates into polar coordinates (x, $y \rightarrow$ r, θ)

The value of θ is obtained within the following limits:

DEG : $0 \leqq |\ \theta\ | \leqq 180$

RAD : $0 \leqq |\ \theta\ | \leqq \pi$

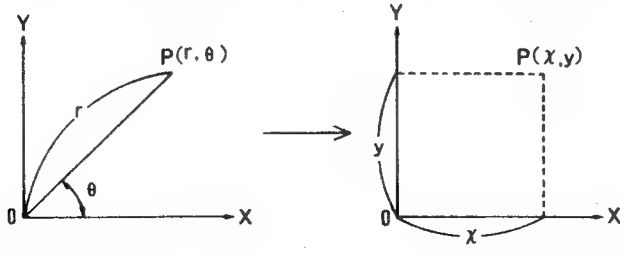
GRAD : $0 \leqq |\ \theta\ | \leqq 200$



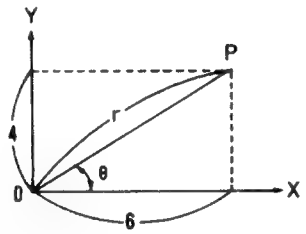
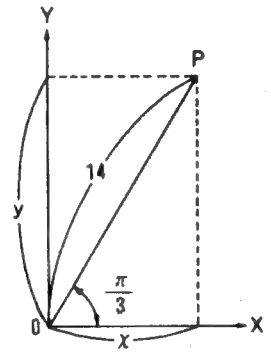
$$r=\sqrt{x^2+y^2},\quad \theta=\mathrm{TAN}^{-1}\frac{y}{x}$$

- Before you start the conversion, press the **2ndF** and **DRG** keys to designate the desired angular unit.
- To obtain the answer for y or θ, key in the **RCL** and **Z** keys.

(2) Conversion of polar coordinates into rectangular coordinates (r, $\theta \rightarrow x$, y)



x=r cosθ, y=r sinθ

Conversion	To solve for	Key in	Your answer
Rectangular to polar coordinates conversion	P(r, θ) = ? DRG:DEG  	6 [→POL] 4 [=] [RCL] [Z]	7.211102551 (r) 33.69006753 (θ)
	Magnitude and direction (phase) of a vector with i=12+j9 DRG:DEG	12 [→POL] 9 [=] [RCL] [Z]	15 (Magnitude) 36.86989765 (Direction)
Polar to rectangular coordinates conversion	P(x, y) = ? DRG:RAD  	14 [2ndF] [→REC] [(] [π] [÷] 3 [)] [=] [RCL] [Z]	7 (x) 12.12435565 (y)

NOTE: In the above examples, key operation **Z** [=] will produce the same result as **RCL Z**.

• Angles

Two keys are used for conversions of angles.

→DEG : Converts an angle in the sexagesimal system (in degrees, minutes, and seconds) into its decimal equivalent (in degrees).

2ndF →D.MS: Converts an angle in the decimal system (in degrees) into its sexagesimal equivalent (in degrees, minutes, and seconds).

Example

Conversion	To solve for	Key in	Your answer
Sexagesimal to decimal angle conversion	12°39′18″=?	12.3918 [→DEG] [=]	12.655
Decimal to sexagesimal angle conversion	123.678°=?	123.678 [2ndF] [→D.MS] [=]	123.404080 (123°40′40″8)
Time calculation	3h30min45sec +)6h45min36sec (total?)	[(] 3.3045 [→DEG] [+] 6.4536 [→DEG] [)] [2ndF] [→D.MS] [=]	10.162100 (10 h 16 min 21 sec)

The calculator can also perform time calculations using the above angular conversion function.

Playback Function

The calculator is provided with a memory area of 160 steps (i.e., input buffer) to temporarily store expressions manually entered for calculation. Operation of the **PB** (Playback) key immediately after the execution of a calculation causes the expression just calculated to be called from the memory area for re-execution.
The **PB** key may also be used to call the previously executed expressions. Expressions calculated are stored in the input buffer in their order of execution until the buffer becomes full and are erased on a first-in first-out (FIFO) basis. In other words, the **PB** key can be used only to access the contents of the input buffer.

Verification and Correction of Expressions Calculated

Key in	Display	Remarks
123 [×] 456 [=]	1 2 3 × 4 5 6	
	5 6 Ø 8 8 .	
987 [÷] 123 [=]	9 8 7 ÷ 1 2 3	
	8 . Ø 2 4 3 9 Ø 2 4 4	
[2ndF] [DRG]		DEG is designated as angular unit.
[SIN] 50 [+] [COS] 45 [=]	S I N 5 Ø + C O S 4 5 =	
	1 . 4 7 3 1 5 1 2 2 4	
[PB]	S I N 5 Ø + C O S 4 5 =	
[PB]	9 8 7 ÷ 1 2 3 =	
[PB]	1 2 3 × 4 5 6 =	
[◁] 7 [=]	5 6 2 1 1 .	
	9 8 7 ÷ 1 2 3 =	

In the above example, the expression first calculated has been corrected to "123 × 457" using the **PB** key.

Clearing Errors with PB key

The playback function is particularly useful in finding the location of an error which may occur during the execution of a calculation, and thus increases efficiency in error processing. If an error message appears during the execution of a calculation, pressing the **PB** key causes the error message to be cleared and the expression that failed to execute to be recalled from the input buffer with the cursor moved to the position immediately after the location where the error exists.

Key in	Display	Remarks
CL 1 ÷ 0 + 5 =	1 ÷ 0 + 5 =	
	ERROR 2	
PB	1 ÷ 0 + 5 =	

In this example, 0 is erroneously used as divisor.

NOTE: Message "ERROR 2" indicates a calculation error. See APPENDIX D for Error Messages.

Clearing Input Buffer

All the contents of the input buffer are cleared on depression of the **2ndF** and **CA** keys.

The contents of the input buffer are also cleared when:

(1) RESET switch is operated
(2) Mode is changed by operating the Mode selector (slide) switch
(3) A program is executed (by operating the **COMP** key)
(4) A program title is searched
(5) MATRIX mode is selected
(6) Data is input on the data screen, data title screen, or x- or y-axis range screen.
(7) Conversion is executed between any two of the binary, octal, hexadecimal, and decimal numbers. (In this case, the conversion expression will not be cleared.)

Key in	Display	Remarks
123 [×] 456 [=]	1 2 3 × 4 5 6 =	
	5 6 Ø 8 8 .	
987 [÷] 123 [=]	9 8 7 ÷ 1 2 3 =	
	8 . Ø 2 4 3 9 Ø 2 4 4	
[CL]	Ø .	

In this example, the screen is cleared by the **CL** key, but the expressions stored in the buffer are retained without change.

Answer Memory Function

In the COMP mode, calculation results obtained with any of the operation execution keys (=, **M+**, **2ndF M+**, ⇒**M** ,**STO A** ~ **STO Z**, →**BIN**, →**OCT**, →**HEX**, →**DEC**) are automatically stored in the answer memory for general calculations (which is different from that for matrix operations), as well as the results of programmed calculations executed by the **COMP** key. The value currently held in the answer memory (i.e., the result of the last computation) can be inserted into any position of the next algebraic expression by using the **2ndF** and **ANS** keys.

Example:
To calculate 12 x 5 ÷ 6.25 + 24 x 3 ÷ 6.25 = where 6.25 is the result of division 50 ÷ 8 = previously performed

Key in	Display	Remarks
CL	0.	
50 ÷ 8 =	5 0 ÷ 8 =	
	6.25	
12.5 × 5 ÷ 2ndF ANS	12.5×5÷6.25_	Recalled from answer memory
+ 24 × 3 ÷ 2ndF ANS	12.5×5÷6.25+24×3	
	÷6.25_	Recalled from answer memory
=	12.5×5÷6.25+24×3	
	÷6.25=	
	21.52	

(The contents of the answer memory have been changed as the result of the operation execution by the = key.)

As in the above examples, the answer memory can be accessed as many times as required. Depression of any of the operation execution keys following **2ndF ANS** causes the contents of the answer memory to be changed.
However, when an attempt to calculate a manually entered expression results in an error, the result of the calculation executed immediately before the expression is retained in memory as the last answer.

Key in	Display	Remarks
5 [÷] 0 [=]	5 ÷ 0 =	
	ERROR 2	
[CL]	0.	
[2nd F] [ANS]	21.52	

The contents of the answer memory will not be cleared even when the calculator enters the Auto Power Off state or is turned off by pressing the **OFF** key, when the mode is changed by operating the mode selector (slide) switch, or when the **CL** or **2ndF** and **CA** key operation is performed.
In the AER-I or AER-II mode, the result of the last computation can be written into a program by operating the **2ndF** and **ANS** keys:

Continuous Calculation & Modify Functions

Continuous Calculation Function

Like the answer memory function, the continuous calculation function allows you to use the result of the calculation last performed for the calculation to be next performed.

Example:
To solve for 3 + 4 = and then multiply the calculation result by 5.

Key in	Display	Remarks
CL	0.	
3 + 4 =	3 + 4 =	
	7.	
× 5 =	7. × 5 =	The next "Multiply" command is input following the result of addition
	35.	

NOTE: The difference of this function from the answer memory function is that the result of the last calculation can be used only at the beginning of the next calculation.

Modify Function

The modify function (**2ndF** and **MDF**) causes the internal result of a calculation stored in memory when used in subsequent calculations, to be in agreement with the format of the result of the calculation in the display. With this calculator, the result of a calculation is obtained to the accuracy of up to 12 digits for mantissa, while all the internally executed calculations are in the exponential form ($A \times 10^B$). The results of all the internal calculations are displayed on the LCD after being converted into the form designated by the display system (FIX, SCI, or ENG) and the number of decimal positions to be fixed (TAB). So, the use of this modify function allows you to use the calculation result in the display without change, for the next calculation to be performed. This function is very useful when you must perform calculations with the significant digits of a number taken into account as in testing or processing the results of experiments.

Example:
To solve for the result of 5 ÷ 9 = and then multiply the calculation result by 9

Key in	Display	Remarks
FSE		To display the FIX indicator
TAB 1	0.0	To fix the number of decimal positions to 1
• Normal calculation		
5 ÷ 9 =	5 ÷ 9 =	
	0.6	
× 9 =	5.6 E −01 × 9 =	Internal result of calculation is multiplied by 9
	5.0	
• Calculation with modify function		
5 ÷ 9 = 2ndF MDF	5 ÷ 9 =	
	0.6	
× 9 =	0.6 × 9 =	
	5.4	

NOTE: In a continuous normal calculation like this example, the value in the display is not used for the calculation. Instead, the value stored in memory is used.

Random Number Generating Function

The calculator has a function to generate pseudo-random numbers in three significant digits ranging from 0.000 to 0.999. To generate random numbers, first press the **2ndF** and **RND** keys, and then the [=] key. Each depression of the [=] key causes random numbers to be displayed on the screen.

This function is useful in selecting data randomly from a group of sample data used in a statistical calculation each numbered consecutively.

	0	1	2	3	4	5	6	7	8	9
0	12	51	53	57	19	41	93	80	50	52
1	45	32	62	68	45	47	87	58	63	(14)
2	73	74	91	75	49	34	32	48	54	39
3	21	68	83	31	(27)	67	69	26	52	16
4	49	74	(12)	22	22	47	7	19	97	87
:	:	:	:	:	:	:	:	:	:	:

Key in	Display	Remarks
[FSE]	0.	Clears FIX, SCI, or ENG symbol displayed
[2ndF] [RND] [=]	RND=	
	0.198	Selects 19th data (14).
[=]	0.426	Selects 42nd data (12)
[=]	0.345	Selects 34th data (27).

NOTE: 1. **2ndF RND** key operation is inoperative in the BIN, OCT, and HEX modes.
2. Value may not be necessarily obtained as shown in the above example due to the nature of random numbers.

Memory Calculations

The calculator has four types of memories for storing numerical data.

(1) Independently accessible memory: One
This memory is accessible by **M+**, **2ndF M+**, ⇒**M**, and **RM** keys and is also used as store memory M.

(2) Memories for constants: 26
These memories are called Store Memories which are accessible by pressing one of the letter keys **A** through **Z** following the **STO** or **RCL** key.

(3) Memory for array variables:
Definable by the DIM statement up to two dimensions.
This memory is mainly used in the MATRIX and STAT modes.

(4) Memory for flexible variables: Definable on a program.
Since this memory is used only in the AER-II mode, its description is provided in Chapter 5.

This section covers memory calculations using the independently accessible memory and the store memories, and also provides an additional description of the array variable memories.

Independent Accessible Memory (M)

• How to use memory

Data movement in and out of the memory is effected by the following three memory control keys.

⇒**M:** Stores the result of calculation in memory.
RM: Recalls the memory contents.
M+: Adds the result of a calculation to the memory contents
2ndF M+: Subtracts the result of a calculation from the memory contents.

• Application examples of memory

Before you start a memory calculation in Example 1, you must press the **CL** (or **0**) key and ⇒**M** keys to clear the memory contents. Press the **FSE** key for the following decimal point system, i.e., until FIX, SCI, and ENG indicators disappear.

MEMORY CALCULATIONS

No.	To solve for	Key in	Your answer
1		CL ⇒M	
	23+45+78=·····①	23 + 45 + 78 M+	①:146
	−52−31+43=·····②	(−) 52 − 31 + 43 M+	②:−40
	+) 64+73−12=·····③	64 + 73 − 12 M+	③:125
	(total) ·····④	RM	④:231
2	24×13=·····①	24 × 13 ⇒M	①:312
	+) 56÷ 7=·····②	56 ÷ 7 M+	②:8
	−) 32× 4=·····③	32 × 4 2ndF M+	③:128
	(total) ·····④	RM	④:192
3		7 × 3 ⇒M	21
	24÷(7×3)=·····①	24 ÷ RM =	①:1.142857143
	(7×3)×5 =·····②	RM × 5 =	②:105

NOTE: 1. **M+**, and **2ndF M+** keys when pressed appear on the display as "M+" and "M−", respectively.
2. Your answer for each expression will appear on the line immediately below the line on which the expression is displayed.
3. In Examples 2 and 3 above, ⇒**M** is used to enter the initial data in the independently accessible memory.
4. In Example 3, the result of multiplication 7 × 3 in calculation ① is first stored in memory and is then recalled to use it as a constant for calculations ① and ②.
5. To subtract a value from the independently accessible memory, operate the **2ndF** and **M+** keys.

Store Memories

● How to use memories

Data movement in and out of each of the 26 store memories is effected by the following two memory control keys and 26 memory designation keys **A** through **Z** .

STO: Clears the contents of the designated memory and stores the number in the display or the result of a calculation in the memory.

RCL: Functions the same as **RM** key.
To clear the contents of a store memory, enter Ø (zero) in the store memory (e.g., 0 **STO** A).

• Application example of store memories
Example:

To solve for	Key in	Your answer
$C = \frac{A\ B}{(A+B)}$ with $A = \frac{(12+6)}{3}$ and $B = \frac{6}{(12-8)}$	(12 + 6) ÷ 3 STO A 6 ÷ (12 − 8) STO B A B ÷ (A + B) STO C	A : 6 B : 1.5 C : 1.2

NOTE: 1. The **STO** key when pressed appears on the display as " ⇒ ".
2. Multiply command "×" may be omitted for multiplication between store memories (e.g., A×B) or for multiplication when a store memory is a multiplier (e.g., 3 × A, 5 × B).

NOTE: In addition to the above method of moving data in and out of each store memory, the result of a calculation can be added to or subtracted from any of the store memories using the **M+** key for addition or the **2ndF** and **M+** keys for subtraction.
(Since store memory M shares the same memory area as the independently accessible memory, the contents of store memory M will change whenever the independently accessible memory is used.)

Key in	Display	Remarks
CL STO M	0.	Contents of memory M are cleared.
3 × 4 M+	3 × 4 M+	
	12.	12 is added to memory M.
5 2ndF M+	5 M−	
	5.	5 is subtracted from memory M.
RCL M	7.	Memory M is accessed.

Example	Key in	Your answer
Store the result of division 4 ÷ 3 into memory A, then perform the following calculation using 4 ÷ 3	4 [÷] 3 [STO] [A]	1.333333333
	[FSE] [TAB] 2 (The number of decimal places is fixed to 2.)	
① When expression written directly with **A** key	2 [A] [×] 3 [=]	8.00
② When expression written with **RCL** and **A** keys	2 [×] [RCL] [A] [×] 3 [=]	7.98

NOTE: 1. In Example ① above, all the contents of memory A (12-digit mantissa and 2-digit exponent) are used, whereas in example ②, only the internal digits of memory A specified by FIX, TAB =2 are used for calculation.

2. The contents of each store memory are retained even when the **CL** or **2ndF CA** key operation is performed or when the calculator enters the Auto Power OFF state or is turned off by pressing the **OFF** key.

Array Variable Memories

With this calculator, array variables can be defined using the DIM (Dimensions) command.

• Definition of array variable

Array variables can be defined in the COMP mode (except BIN, OCT, and HEX submodes), as well as in the AER-I or AER-II mode.

Examples: In COMP mode

[2ndF] [DIM] [A] [2ndF] [(] 5 [,] 5 [2ndF] [)] [=/SET]

By the above key operation, array variable A [5 , 5] with variable name "A" and a size (dimension) of 5 rows by 5 columns is defined.

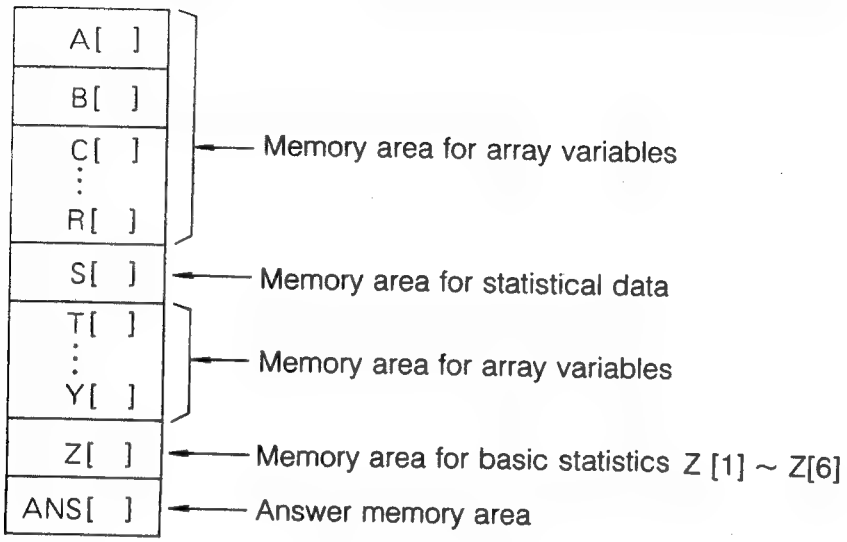
In AER-I or AER-II

[2ndF] [DIM] [A] [2ndF] [(] 5 [,] 5 [2ndF] [)]

By writing the above key sequence in a program, array variable A [5 , 5] is defined.

• Array variable memory areas

The memory areas for array variables are configured as shown below.



The usage of array variables is detailed in Matrix Operations, this chapter and in Statistical Calculations, Chapter 3.

Binary, Octal, & Hexadecimal Number Calculations

The calculator can perform conversions between any two of decimal, binary, octal, and hexadecimal numbers, and also perform four basic arithmetic operations on numbers expressed in these number systems. Decimal fractions are only possible in the DEC mode.

Number System Modes

To perform conversions between any two of decimal, binary, octal, and hexadecimal numbers, the calculator must be set in one of the following number system modes as applicable, with the Mode Selector switch in the COMP position.

2ndF →BIN

: Binary Number System (BIN) Mode.

- Displays 16-digit binary numbers.
- Converts the number in the display into its binary equivalent. When these two keys are pressed, the **BIN** indicator appears at the bottom part of the display.
- If an expression is in the display, the calculator performs the calculation of the expression and converts the calculation result into a binary number.
- In this mode, only **0** and **1** keys can be used. The other number keys and decimal point key thus become inoperative.

2ndF →OCT

: Octal Number System (OCT) Mode

- Displays 10-digit octal numbers.
- Converts the number in the display into its octal equivalent. When these two keys are pressed, the **OCT** indicator appears at the bottom part of the display.
- If an expression is in the display, the calculator performs the calculation of the expression and converts the calculation result into an octal number.
- In this mode, only **0** through **7** keys can be used. The other number keys and decimal point key thus become inoperative.

2ndF →HEX

: Hexadecimal Number System (HEX) Mode

- Displays 10-digit hexadecimal numbers.
- Converts the number in the display into its hexadecimal equivalent. When these two keys are pressed, the **HEX** indicator appears at the bottom part of the display.
- If an expression is in the display, the calculator performs the calculation of the expression and converts the calculation result in a hexadecimal number.
- In this mode, numeral keys **0** through **9** and hexadecimal number keys **A** through **F** (**Y^x**, **LOG**, **LN**, X^2, $\sqrt{\ }$, π) can be used. The decimal point key alone thus becomes inoperative.

2ndF →DEC

: Decimal Number System (DEC) Mode

• Converts the number in the display into its decimal equivalent. When these two keys are pressed, no decimal number system indicator appears in the display. Since the calculator normally uses this number system, the absence of any number system indicator means that the unit is in the decimal number system mode.

• If an expression is in the display, the calculator performs the calculation of the expression and converts the calculation result into a decimal number.

• In this mode, numeral keys **0** through **9** are used to perform four basic arithmetic operations and scientific calculations.

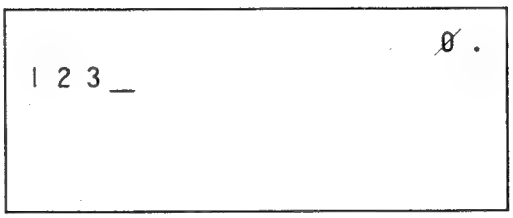
Cross-reference table for four basic notations

Decimal	Binary	Octal	Hexadecimal
0	0	0	0
1	1	1	1
2	10	2	2
3	11	3	3
4	100	4	4
5	101	5	5
6	110	6	6
7	111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F
16	10000	20	10
17	10001	21	11
18	10010	22	12
19	10011	23	13
20	10100	24	14

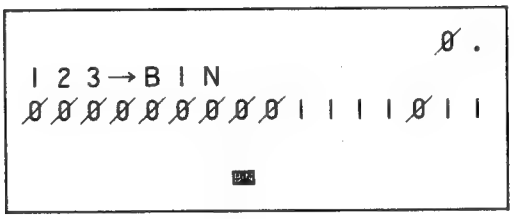
Conversions of Binary, Octal, Decimal, & Hexadecimal Numbers

Before we go into conversion exercises, let's see how the binary, octal, and hexadecimal numbers will appear on the display by converting decimal number 123 into its binary, octal, and hexadecimal equivalents.

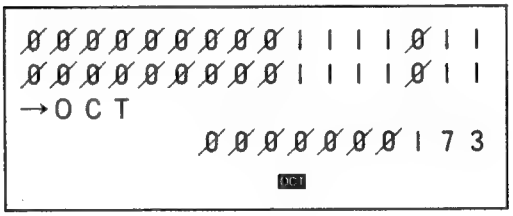
[CL] [2 ndF] [→DEC] 123



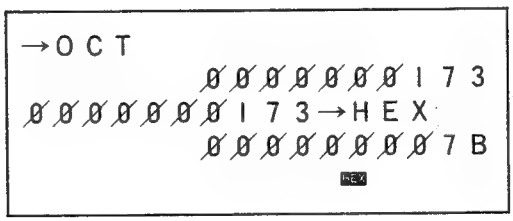
[2 ndF] [→BIN]



[2 ndF] [→OCT]



[2 ndF] [→HEX]



The numbers converted into binary, octal, and hexadecimal equivalents are displayed in the complete number of digits specified for calculation in the respective number systems.

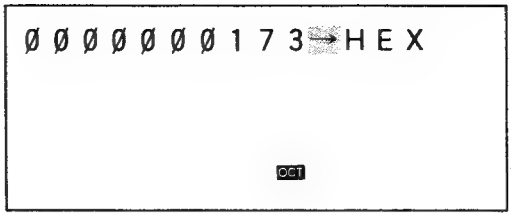
No.	To convert	Key in	Your answer
1	Decimal number 19 into its binary equivalent.	2ndF →DEC 19 2ndF →BIN	10011
2	Hexadecimal number 2BC into its decimal equivalent.	2ndF →HEX 2BC 2ndF →DEC	700
3	Octal number 52 into its hexadecimal equivalent.	2ndF →OCT 52 2ndF →HEX	2A
4	Decimal number 12.34 into its hexadecimal equivalent.	2ndF →DEC 12.34 2ndF →HEX	C
5	Decimal number −1 into its binary, octal, and hexadecimal equivalents.	2ndF →DEC (−) 1 2ndF →BIN 2ndF →OCT 2ndF →HEX	1111111111111111 (two's complement) 7777777777 (eight's complement) FFFFFFFFFF (16's complement)

NOTE: 1. Use the hexadecimal number keys $\mathbf{Y}^x$, **LOG**, **LN**, x^2, $\sqrt{\ }$, and π to enter **A**, **B**, **C**, **D**, **E**, and **F** in the HEX mode.
2. When converting a decimal number with fractions into its binary, octal, or hexadecimal equivalent as in Example 4 above, the fractional part of the number (e.g., 0.34) is truncated and only the integer part (e.g., 12) is converted.
3. As in Example 5, a negative decimal number when converted is displayed as a complement corresponding to the designated number system.

• Use of **PB** key in BIN, OCT, or HEX mode

Immediately after the conversion into a binary, octal, or hexadecimal number, depression of the **PB** key allows the conversion expression to be displayed in the mode before the conversion. (This playback function is effective only one time. In other words, subsequent depressions of the **PB** key will not cause the expression before the conversion to be displayed again.)

PB



NOTE: 1. An error will result if an attempt is made to convert or calculate a binary, octal, or hexadecimal number entered in excess of the number of digits specified for each number system (i.e., 16 digits for binary numbers and 10 digits for octal and hexadecimal numbers). An error will also result when the result of a binary, octal, or hexadecimal number conversion exceeds the range of calculation specified for each mode. (See APPENDIX B for Accuracy of Calculation.)

2. If an error occurs as a result of the **2ndF →BIN, 2ndF →OCT, 2ndF →HEX**, or **2ndF →DEC** operation, the designated mode conversion will not take place.

Binary, Octal, & Hexadecimal Number Calculations

With this calculator, four basic arithmetic operations (add, subtract, multiply, and divide) and memory calculations can be performed in the BIN, OCT, and HEX modes just the same as in the normal DEC mode. (In other than the DEC mode, scientific functions cannot be performed.)

- Calculations in BIN mode

No.	To solve for	Key in	Your answer
1	1011 + 1110 =	CL 2ndF →BIN 1011 + 1110 =	11001
2	(1010 − 100) × 11 =	(1010 − 100) × 11 =	10010

• Calculations in OCT mode

No.	To solve for	Key in	Your answer
1	5 + 7 =	CL 2ndF OCT 5 + 7 =	14
2	32 ÷ 2 =	32 ÷ 2 =	15
3	5 ÷ 2 =	5 ÷ 2 =	2

NOTE: If the result or intermediate result of a binary, octal, or hexadecimal calculation turns out to be a number with a fraction part as in Example 3 above, the result is displayed with its fraction part truncated.

• Calculations in HEX mode

No.	To solve for	Key in	Your answer
1	2FF − 25 =	CL 2ndF →HEX 2FF − 25 =	2DA
2	(2000 − 1FC) ÷ 2 =	(2000 − 1FC) ÷ 2 =	F02

• Mixed calculations

To perform	Key in	Your answer
Addition of decimal number 512 to hexadecimal number 1FFH and conversion of the calculation result into its binary equivalent.	CL 2ndF →DEC 512 2ndF →HEX + 1FFF 2ndF →BIN	10000111111111

NOTE: In the BIN, OCT, or HEX mode, a negative binary, octal, or hexadecimal number is entered using the **NEG** (**(−)**) key (i.e., to obtain the complement of the binary, octal, or hexadecimal number).

Logical Operations

The calculator can perform logical NOT, AND, OR, XOR (exclusive OR), and XNOR (exclusive NOR) operations on binary, octal, and hexadecimal numbers. To enter logical operators, NOT, AND, OR, XOR, and XNOR, use the **SIN**, **COS**, **TAN**, **→DEG**, and **→POL** keys, respectively, on the left-hand keyboard. The function printed in yellow above each of these keys will be entered.

The truth tables of the logical operations are as shown below.

A	B	A AND B	A OR B
0	0	0	0
1	0	0	1
0	1	0	1
1	1	1	1

A	B	A XOR B	A XNOR B
0	0	0	1
1	0	1	0
0	1	1	0
1	1	0	1

A	NOT A
0	1
1	0

No.	To perform	Key in	Your answer
1	AND operation of binary numbers 1101 and 111	CL 2ndF →BIN 1101 AND 111 =	101
2	OR operation of hexadecimal numbers 5B and F3	CL 2ndF →HEX 5 B OR F 3 =	FB
3	NOT operation of binary number 101011	CL 2ndF →BIN NOT 101011 =	1111111111010100
4	Exclusive-OR operation of octal numbers 26 and 54	CL 2ndF →OCT 26 XOR 54 =	72
5	OR operation of hexadecimal number 8E and binary number 11101	CL 2ndF →HEX 8E 2ndF →BIN OR 11101 =	10011111

LOGICAL OPERATIONS

No.	To perform	Key in	Your answer
6	Exclusive-NOR operation of hexadecimal numbers **A5** and **2F**	CL 2ndF →HEX A 5 XNOR 2 F =	FFFFFFFF75
7	AND operation of hexadecimal number **F5** and the result of OR operation of hexadecimal numbers 84 and **7E**	CL 2ndF →HEX (84 OR 7 E) AND F 5 =	F4

Matrix Operations

The calculator can perform the following types of matrix operations as per algebraic expressions when the submode "MATRIX" is selected with the calculator in the COMP mode.

Types of Matrix Operations

- Four basic (Add, Subtract, Multiply, and Divide) operations between two matrixes

  Example: MAT A + MAT B, MAT A − MAT B
  MAT A × MAT B, MAT A ÷ MAT B

In division, the inverse matrix of matrix B (divisor) is first obtained and then multiplied by matrix A (dividend).

- Four basic operations between scalar n and a matrix

(1) In addition, scalar n is added to each matrix element (n + MAT A).
(2) In subtraction, each matrix element is subtracted from scalar n (n − MAT A).
(3) In multiplication, each matrix element is multiplied by scalar n (n × MAT A).
(4) In division, each inverse matrix element is divided by scalar n (n × MAT A^{-1}).

- Calculation of determinant value

Example: DET MAT A, DET MAT B

- Inverse matrix

Example: MAT A^{-1}

To perform this operation, matrix A must be a square matrix (DET A ≠ 0). Multiplication of an inverse matrix by scalar n (MAT A^{-1} × n) is executed as n ÷ MAT A.

- Transposition of matrix

A transposed matrix refers to a new matrix (n, m type) which is obtained from the original matrix (m, n type) by interchanging the rows and columns of its respective elements.

Example: TRANS MAT A

- Squaring of matrix

Example: MAT A^2

To perform this operation, matrix A must be a square matrix.

• Sign change
The positive or negative sign of each matrix element is reversed in this operation.
Example: −MAT A

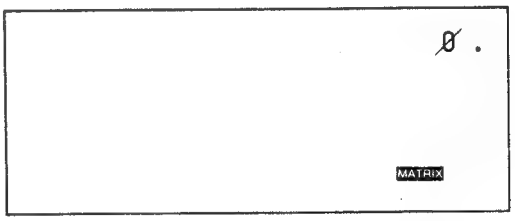
Special Keys for Matrix Operations
The following keys located on the right-hand keyboard are used exclusively for matrix operations:

MAT : Used to define a matrix (e.g., MAT A)
2ndF DET : Used to define a determinant (e.g., DET MAT A)
2ndF TRANS: Used to define a transposed matrix (e.g., TRANS MAT A)
2ndF x^{-1} : Used to define an inverse matrix (e.g., MAT A^{-1})
2ndF DIM :
2ndF [:
2ndF] : } Used to define the dimension of an array

NOTE: Although the **MAT** key is also the second function, **2ndF** key needs not be pressed before this key in the MATRIX mode.

Matrix Mode
Before you start a matrix operation, you must place the calculator in the MATRIX mode, and then define the matrixes you use for calculation.
To set the MATRIX mode, make sure that the Mode Selector switch is in the COMP position, and then press the **2ndF** and **MATRIX** keys, and the MATRIX indicator will appear at the bottom part of the display and "Ø." at the rightmost position in the top row of the display.

2ndF MATRIX



To release the calculator from the MATRIX mode, press the **2ndF** and **MATRIX** keys a second time.

Definition of Matrixes
• Matrix name
Within an expression, the name of each matrix must be defined by the symbol "MAT" followed by one of the 26 letters (A through Z), for example, MAT A, MAT B.

• Matrix elements
The data for each element of a matrix must be entered using two-dimensional array variables that appear on the data screen.

• Data input procedure
1. Press the **2ndF** and **MATRIX** keys to set the MATRIX mode.
2. Press the **2ndF** and **DIM** keys and enter the name and size (columns, rows) of a matrix. Columns and rows must be enclosed in brackets as shown below.
   2ndF DIM Matrix name **2ndF [** Columns , Rows **2ndF]**
3. Press the **SET** (=) key and the display automatically changes to the data screen.
4. Enter the data (or value) for each element of the matrix by pressing the **SET (=)** key following each data input.
   The correspondence of the values of the respective matrix elements is as shown below.

   Example: When DIM A [3, 3] is defined

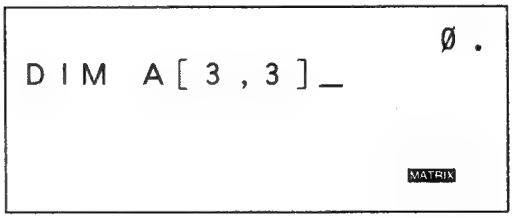
   A [1,1] A [1,2] A [1,3]
   A [2,1] A [2,2] A [2,3]
   A [3,1] A [3,2] A [3,3]

Example 1:
Define the following two matrixes A and B.

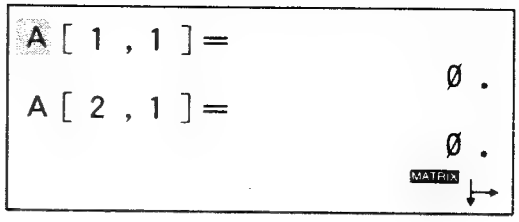
$$A=\begin{pmatrix}1 & 2 & 3\\ 4 & 5 & 6\\ 7 & 8 & 9\end{pmatrix} \qquad B=\begin{pmatrix}5 & 6 & 7\\ 2 & 3 & 4\\ 8 & 9 & 1\end{pmatrix}$$

To define matrix A:

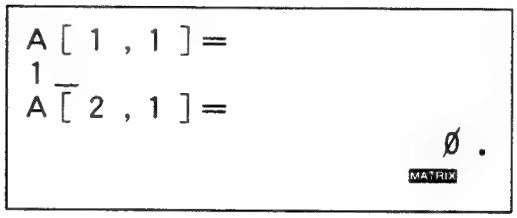
[2ndF] [DIM] [A] [2ndF]
[[ ] 3 [,] 3 [2ndF] [ ]]



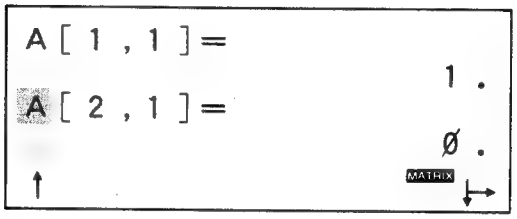
[=SET]



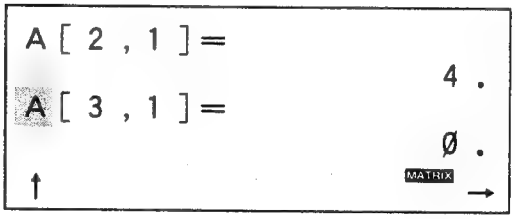
1



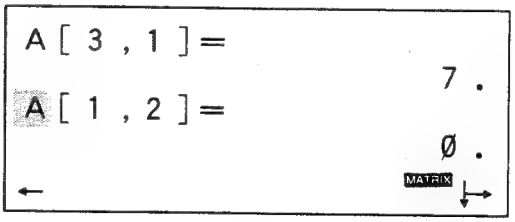
[=SET]



4 [=SET]

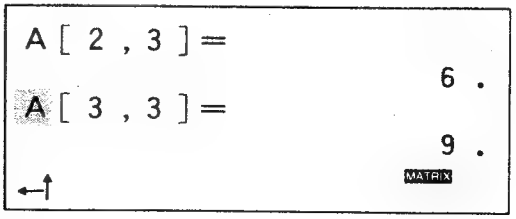


7 [=SET]



⋮

9 [=SET]

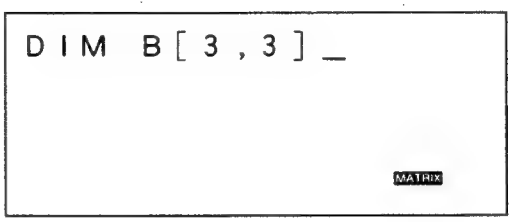


To define matrix B:

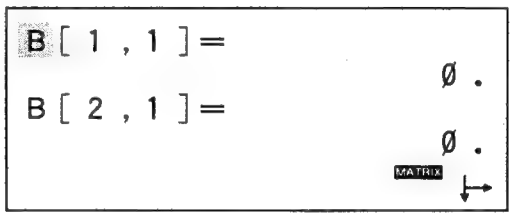
After all the matrix elements of matrix A have been set, operation of **2ndF** and **DIM** keys to define matrix B causes the display screen to automatically change to the text screen mode. Enter the data for each element of matrix B in the same manner as above.

2ndF DIM B 2ndF

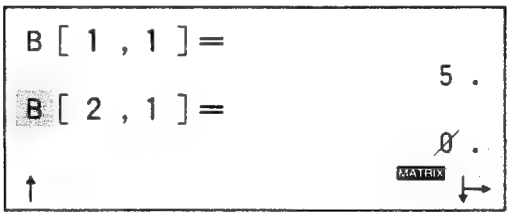
[3 , 3 2ndF]



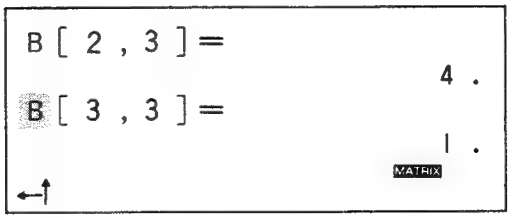
=/SET



5 =/SET



1 =/SET



NOTE: When the dimension of a matrix is defined, memory space is used as follows.
Number of data × 8 (steps) + (6 steps)
Example: A [2, 2]
4 × 8 (steps) + (6 steps) = 38 steps (or bytes)

Matrix Operation Examples

Using the two matrixes just defined, let's try some matrix operations.
Before you enter the matrix expression, you must change the display from the data screen to the text screen by operating the **2ndF** and **T▶G▶D** keys.

No.	Operation	Key in	Your answer
1	Adding matrix A to matrix B	MAT A + MAT B =	ANS(1,1):6
		▽	ANS(2,1):6
		▽	ANS(3,1):15
		▽	ANS(1,2):8
		▽	ANS(2,2):8
		▽	ANS(3,2):17
		▽	ANS(1,3):10
		▽	ANS(2,3):10
		▽	ANS(3,3):10

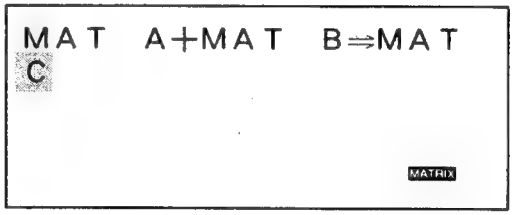
The execution of the matrix operation by pressing the [=] key causes the display to automatically change to the data screen and each element stored in the answer memory to be displayed as a solution (ANS) to the matrix operation.
Verify each matrix element which serves as the solution using the [△], [▽], [▷] and [◁] keys.

NOTE: Operation of the **2ndF** and **T▶G▶D** keys in the data screen mode causes the display to return to the text screen.

No.	Operation	Key in	Your answer
2	Adding matrixes A and B and storing the calculation result to array C	MAT A + MAT B STO MAT C ▽ ⋮ ▽	ANS(1,1):6 ANS(2,1):6 ⋮ ANS(3,3):10

NOTE: The contents of the answer memory are displayed on the data screen. The result of addition MAT A + MAT B are stored in both the answer memory and array C.

2ndF T▶G▶D PB



NOTE: The **PB** key is inoperative while the contents of the answer memory are being displayed on the data screen. The key works only after the data screen has been changed to the text screen by operating the **2ndF** and **T▶G▶D** keys.

No.	Operation	Key in	Your answer
3	Calculating the value of the following determinant: $\begin{vmatrix} 5 & 6 & 7 \\ 2 & 3 & 4 \\ 8 & 9 & 1 \end{vmatrix}$	2ndF DET MAT B =	−27
4	Multiplying each element of matrix A by scalar n (n = 2) $A = \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix} \times 2$	MAT A × 2 = ▽ ⋮ ▽	ANS(1,1):2 ANS(2,1):8 ANS(3,1):14 ⋮ ANS(3,3):18

No.	Operation	Key in	Your answer
5	Obtaining the inverse of matrix B	MAT B 2ndF x^{-1} = ▽ ⋮ ▽	ANS(1,1): 1.222222222 ANS(2,1): −1.111111111 ⋮ ANS(3,3): −0.111111111
6	Obtaining the transposed matrix of matrix A $A=\begin{pmatrix}1&2&3\\4&5&6\\7&8&9\end{pmatrix}\rightarrow\begin{pmatrix}1&4&7\\2&5&8\\3&6&9\end{pmatrix}$	2ndF TRANS MAT A = ▽ ⋮ ▽	ANS(1,1):1 ANS(2,1):2 ANS(3,1):3 ⋮ ANS(3,3):9
7	Squaring matrix A	MAT A x^2 = ▽ ▽ ⋮ ▽	ANS(1,1):30 ANS(2,1):60 ANS(3,1):102 ⋮ ANS(3,3):150

Write Protect Function

To prevent any of the data entered in an array variable memory from being overwritten or erased, the data can be write protected. To do this, move the cursor to the position (i.e., array or matrix name) at which the data to be protected exists by operating the **DATA (TITLE)** key and ▷ or △ key in the COMP mode. Then press the **2ndF** and **PROTECT** keys and symbol "P" will appear at the right of the array name line, indicating that all the data in the array (or matrix) have been write protected.

To release the data from the Write Protected state, move the cursor to the position where the protected data exists in the same manner as above and then press the **2ndF** and **PROTECT** keys and symbol "P" will disappear. Note that all the data stored in the answer memory (ANS) are automatically write protected.

CHAPTER 3
OPERATIONS IN STAT MODE

The calculator can perform single- and two-variable statistical calculations as well as draw six different statistical graphs on the graphic screen in the primary mode of operation called the STAT (Statistical calculation) mode. Depending on whether or not you want to keep statistical data for later use, you must select either of the two submodes: DATA STORE and NON-STORE.
In the DATA STORE mode, all statistical data that you entered for calculation are stored in the memory area dedicated to statistical data and will be retained even when the calculator enters the Auto Power Off state or is turned off by operating the **OFF** key or when the calculator mode is changed to other than STAT by operating the Mode Selector switch.
In the NON-STORE mode, each statistical data entry is used for calculation to obtain statistics such as the number of samples (n), sum total of samples (Σx), sum of squares of samples (Σx^2), and sum of the product of samples x and y, (Σxy) and therefore, the input data itself will not be retained in memory.
The graphics feature of the calculator in the STAT mode includes histogram, broken-line graph, cumulative frequency graph, normal distribution graph, scatter diagram, and linear regression. This feature is detailed in Chapter 4.

DATA STORE Mode and NON-STORE Mode Selection

Before performing a statistical calculation, you must place the calculator in the STAT mode. To do so, set the Mode Selector switch in the STAT position and a menu screen will appear as an initial screen to allow selection of the DATA STORE or NON-STORE mode.

Mode Selection Menu Screen


```
STAT MODE
data store → 1
  non-store → 2
```

Press the numeric **1** key to select the DATA STORE mode or the numeric **2** key to select the NON-STORE mode.
Symbol "DT.STO" will appear at the bottom part of the display when the numeric **1** key is pressed to select the DATA STORE mode.

Initial screen of DATA STORE mode

[1]

```
DATA STORE MODE
S:[0, 0], P
 :
                    0.
DT.STO
```

Initial screen of NON-STORE mode

[2]

```
NON-STORE MODE
                    0.
```

Memories For Statistical Data & Statistics

• Array Variable Memories S and Z

In the DATA STORE mode, all data entered for a statistical calculation are stored in array variable memory S (area for statistical data input) in their order of input. The results of the statistical calculation (i.e., basic statistics) are stored in array variable memory Z (Z[1] through Z [6]).

The data stored in array variable memory S (area for statistical data input) and Z (areas for statistics) are automatically write protected, thus prohibiting data rewrite in the COMP mode.

Before we go into details on how to enter statistical data and perform calculations, let's review briefly what statistics we can get from a single-variable or two-variable statistical calculation in both the DATA STORE and NON-STORE modes.

•Statistics Obtainable from Calculation

In both the DATA STORE and NON-STORE modes, the following statistics can be obtained.

• Single-variable statistics

(1) n : Number of samples
(2) Σx : Sum total of samples
(3) Σx^2 : Sum of squares of samples
(4) $\bar{x}$: Mean value of samples

$$\bar{x} = \frac{\Sigma x}{n}$$

(5) sx : Standard deviation with population parameter taken as "n-1".

$$sx = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n-1}}$$

(Used to estimate the standard deviation of a population from the sample data extracted from that population.)

(6) σx: Standard deviation with population parameter taken as "n".

$$\sigma x = \sqrt{\frac{\Sigma x^2 - n\bar{x}^2}{n}}$$

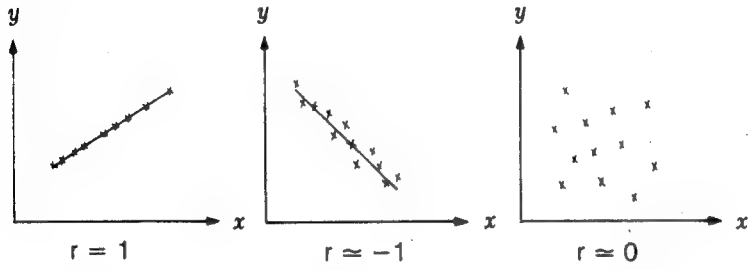
(Used when all populations are taken as sample data or when finding the standard deviation of a population with samples taken as that population.)

• Two-variable statistics

Statistics for both x and y such as n, Σx, $\bar{x}$, Σx^2, sx, σx, and Σy, $\bar{y}$, Σy^2, sy σy are the same as those for x in single-variable statistics, except that samples should be identified as x and y, respectively. In addition, Σxy (the sum of the product of samples x and y) is obtained in this calculation.

In Linear Regression there are three important values; r, a, and b. The correlation coefficient r shows the quantitative relationship between two variables x and y for a particular sample. The value of r is between −1 and 1. If r equals −1 or 1, all points on the correlation diagram are on a line.

The further the value of r is from −1 or 1, the less the points that are massing about the line. The closer the value of r to 0, the less reliable is the correlation. If r is more than 0, it shows a positive correlation (y is in proportion to x) and if r is less than 0, it is a negative correlation (y is in inverse proportion to x).



The equation for the straight line is $y = a + bx$. The point at which the line crosses the y axis is a. The slope is b.

r: Correlation coefficient

$$r = \frac{Sxy}{\sqrt{Sxx \cdot Syy}}$$

$$\left(\begin{array}{l} Sxx = \Sigma x^2 - \dfrac{(\Sigma x)^2}{n} \\ Syy = \Sigma y^2 - \dfrac{(\Sigma y)^2}{n} \\ Sxy = \Sigma xy - \dfrac{\Sigma x \cdot \Sigma y}{n} \end{array} \right)$$

$$a = \bar{y} - b\,\bar{x}$$

$$b = \frac{S\,xy}{S\,xx}$$

Coefficient of linear regression
equation $y = a + bx$
x': Estimated value (the value of x is estimated from that of y.)

$$x' = \frac{y - a}{b}$$

y': Estimated value (the value of y is estimated from that of x.)

$y' = a + bx$

• Keys used for statistical calculations

Keys used to obtain the above statistics ($\bar{y}$, $\bar{x}$, Σxy, **n**, sy, sx, σy, σx, Σy, Σx, Σy^2, Σx^2, (**r**), (**a**), (**b**), (x'), and (y') and those used to enter and correct statistical data (**CD**, (x,y), and DATA) are conveniently located side by side at the lower half of the lefthand keyboard.

• Areas for statistics

Of all the statistics, the following will be stored in areas Z[1] through Z[6] of array variable memory Z in both the DATA STORE and NON-STORE modes as shown below.

Memory area	Z [1]	Z [2]	Z [3]	Z [4]	Z [5]	Z [6]
Statistics	n	Σx	Σx^2	Σxy	Σy	Σy^2

To clear the basic statistics from the above memory areas in the NON-STORE mode, operate the **2ndF** and **CA** keys. In this case, the statistical data stored in array variable memory S will be retained.

To clear the basic statistics in the DATA STORE mode, press the **2ndF**, **CA** and **ENT** keys following the **DATA (TITLE)** key operation and all the statistical data and statistics stored in array variable memories S and Z, respectively, will be cleared.

Also in the STAT mode, **STO A** ~ **STO Z** and **RCL A** ~ **RCL Z** can be used. The contents of store memories A through Z are retained even when a statistical calculation is performed.

Data Input Formats

The same data input format will be used in both the DATA STORE and NON-STORE modes.

- **To enter data one by one**
  - Single-variable data
    Numerical data [DATA]
  - Two-variable data
    Numerical data (x) [(x,y)] Numerical data (y) [DATA]

- **To enter two or more of the same data**
  - Single-variable data
    Numerical data [×] Frequency [DATA]
  - Two-variable data
    Numerical data (x) [(x,y)] Numerical data (y) [×] Frequency [DATA]

NOTE: Data can be input in the form of an expression. However, the expression must be parenthesized when the +, −, ×, or ÷ command is used in the expression.

Example: (5 + 4 × 3) [DATA]

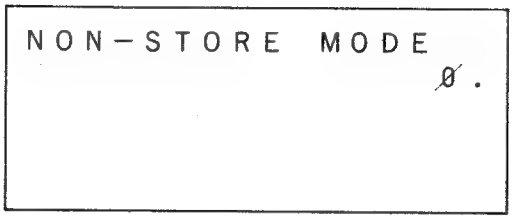
In the above example, if the expression was not parenthesized, 5 + would be ignored, and the same result would be returned as in key operation 4 × 3 [DATA]

Operations in NON-STORE mode

When you select the NON-STORE mode by pressing the numeric **2** key, the following text screen appears on the display.

NON-STORE MODE

[2]



For the convenience of explanation, let's use single-variable data in the following example.

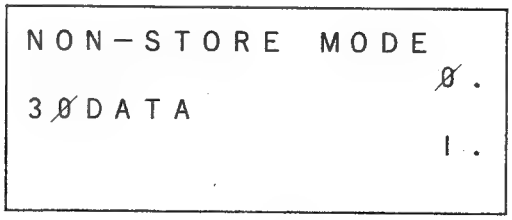
Example:
To solve for the mean value and standard deviation of the marks in an examination (i.e., data x) of randomly selected 35 students (i.e., samples) shown in the table below.

Data No.	Marks in exam	No. of students	Data No.	Marks in exam	No. of students
1	30	1	5	70	8
2	40	1	6	80	9
3	50	4	7	90	5
4	60	5	8	100	2

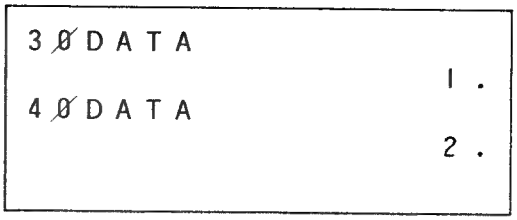
- **Data entries**

Enter each data from the table according to the data input format for single-variable data using the [×] (Frequency) and [DATA] keys.

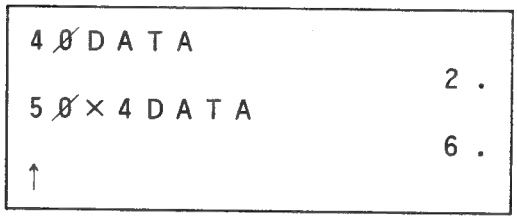
30 [DATA]



40 DATA

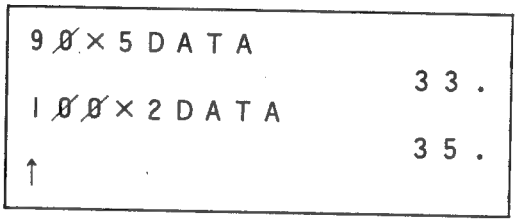


50 × 4 DATA



⋮

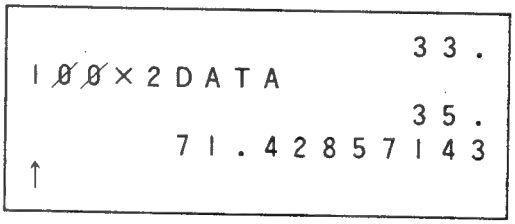
100 × 2 DATA



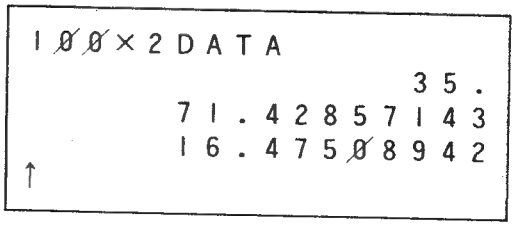
• Calculation

After you have completed all required data entries from the table, simply press the respective statistical calculation keys of the statistics that you wish to obtain ($\bar{x}$ for mean value and s_x for standard deviation) followed by the **2ndF** key.

2 ndF $\bar{x}$



2 ndF S_x



You can get other statistics in the same way as above. Your answer for the rest of the statistics should be:
n (number of samples): 35
Σx (Sum total of samples) : 2500
Σx^2 (Sum of squares of samples): 187800

NOTE: 1. After all the data have been entered, statistics such as mean value, standard deviation, etc., may be obtained in any desired order.
2. After a mean value, standard deviation, or any other statistic has been obtained as an intermediate result, more data can be entered and statistical calculations can be performed continuously on additional data entry.
3. The DATA key may be pressed consecutively to enter two or more of the same data instead of key operation; [×] Frequency [DATA].

• Data entry correction
If an erroneous data has been entered, the incorrect entry can be corrected using the **CD** key.

Example:
To correct the marks of data No. 3 erroneously entered as 55 instead of 50 in the above example

[2ndF] [CA]
30 [DATA] 40 [DATA]
55 [×] 4 [DATA]

```
4 Ø DATA
                    2 .
5 5 × 4 DATA
                    6 .
↑
```

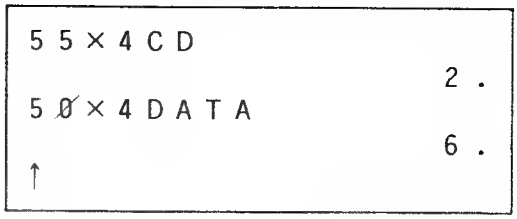
(Incorrect data is input)

55 [×] 4 [CD]

```
5 5 × 4 DATA
                    6 .
5 5 × 4 CD
                    2 .
↑
```

(Incorrect data is cleared.)

50 [×] 4 [DATA]



(Correct data is input.)

NOTE: 1. An erroneous data entry before pressing the [DATA] key can be cleared by the **CL** key. The correct data may then be entered.
2. To perform a new statistical calculation, press the **2ndF** and **CA** keys to clear the basic statistics stored in array variable memory Z.

Operations in DATA STORE Mode

When you select the DATA STORE mode by pressing the numeric **1** key, the following data screen appears.

1

```
DATA  STORE  MODE
S:[Ø, Ø], P
 :
                    Ø.
        DT.STO
```

"S" on the screen indicates that array variable memory S is accessed and "[Ø,Ø]" indicates that nothing is stored in memory S. With the data screen in this state, you can enter data for a statistical calculation.

```
DATA  STORE  MODE
S:[ 2, 3Ø], P
 :TEST

        DT.STO
```

If the data screen looks like this, it means that some data have already been stored in memory S. If you enter data for a statistical calculation with the screen in this state, the new data will be added to the data previously stored in the memory. If you wish to enter new statistical data while retaining the previously stored data, employ memory S by moving its contents (i.e., previous data) to an unused array variable memory (other than S, Z, and ANS) and then proceed to the data input and data title entry operations described below. Refer to the last page of this chapter for data transfer to another array variable memory.

NOTE: 1. The specification of array variable memory S to either a single variable (one dimension) or two variables (two dimensions) is automatically determined depending on whether the data first entered in the memory is a single variable or two variables. An error will result if you attempt to enter a two-variable data during the input operation of single-variable data. Unlike MATRIX mode, the dimension of the array needs not be defined, because the dimension of array variable memory S will be automatically expanded at each data input.

2. In the DATA STORE mode, all the data stored in array variable memory S are automatically write protected. (Therefore, the statistical data entered cannot be released from the write protected state in this mode.)

• Data entries

When the following text screen appears by pressing the numeric **1** key to select the DATA STORE mode, the calculator is ready to accept data input.

1

```
DATA  STORE  MODE
S:[ 0, 0], P
 :
                    0.
DT.STO
```

Let's enter the following two-variable data in the specified input format.

Data \ No.	1	2	3
x	15	8	35
y	20	13	17

Be sure to press the DATA key following each statistical data entry.

15 (x,y) 20 DATA

```
 :
                    0.
15, 20DATA
                    1.
DT.STO
```

8 (x,y) 13 DATA

```
15, 20DATA
                    1.
8, 13DATA
                    2.
DT.STO
```

35 (x,y) 17 DATA

```
8, 13DATA
                    2.
35, 17DATA
                    3.
↑       DT.STO
```

• Data title entry

After all the data for the statistical calculation have been entered, press **DATA (TITLE)** key followed by the [▷] key and the calculator is in the state to accept a data title input. Enter the data title name (e.g., TEST 1) and they press **SET (=)** key to complete the data title entry.

[TITLE/DATA] [▷]

```
S : [ 2, 3] , P
  : _
```

[T][E][S][T] 1 [=/SET]

```
S : [ 2, 3] , P
  : T E S T 1
```

NOTE: A data title name cannot be entered without any data stored in array variable memory S. Be sure to perform the data entry operation before you enter the data title name.

• Verifying and correcting input data

Any of the statistical data entered in array variable memory S (i.e., statistical data input area) can be verified and corrected on the data screen.

Data verification

Statistical data entered are stored in array within array variable memory S as follows.

• Single-variable data

x_1 [1]
x_2 [2]
x_3 [3]
⋮

• Two-variable data

x_1 [1, 1]	x_2 [1, 2]	x_3 [1, 3]	....
y_1 [2, 1]	y_2 [2, 2]	y_3 [2, 3]	

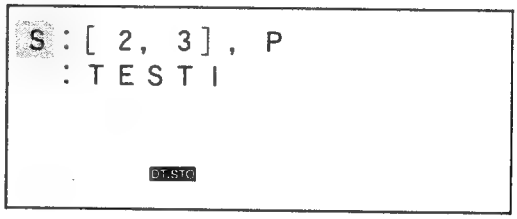
Single- and two-variable data can be searched, in the following sequence with the [▽] or [△]

- Single-variable data $x_1 \rightarrow x_2 \rightarrow x_3 \cdots\cdots$ or $\cdots\cdots x_3 \rightarrow x_2 \rightarrow x_1$
- Two-variable data $(x_1 \rightarrow y_1) \rightarrow (x_2 \rightarrow y_2) \rightarrow (x_3 \rightarrow y_3) \cdots\cdots$ or
  $\cdots\cdots (x_3 \rightarrow y_3) \rightarrow (x_2 \rightarrow y_2) \rightarrow (x_1 \rightarrow y_1)$

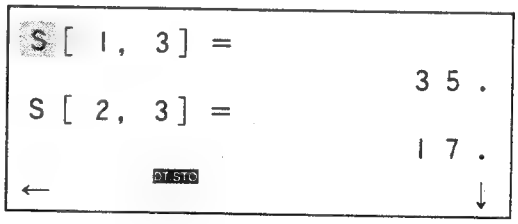
After statistical data input area S has been accessed by pressing the **DATA (TITLE)** key, press the **SET (=)** key and the display screen automatically changes to the data screen. In this state, flashing the cursor appears at the position of the last input data.

NOTE: In the STAT mode, the **DATA (TITLE)** key can access statistical data input area S only.

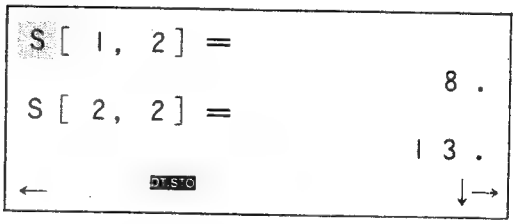
[TITLE DATA]



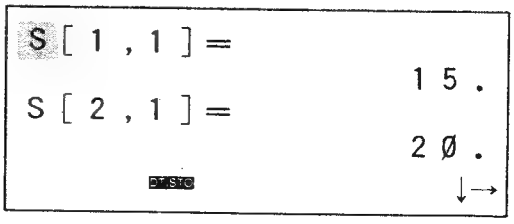
[=] SET



[△] [△]



[△] [△]



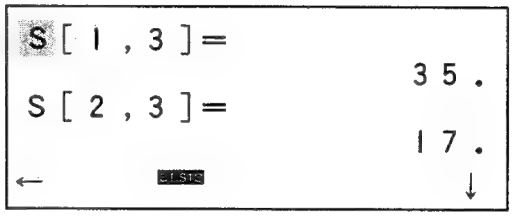
By changing the data screen to the text screen with the **2ndF T▶G▶D** key operation, you may continue the data entry operation.

Data correction

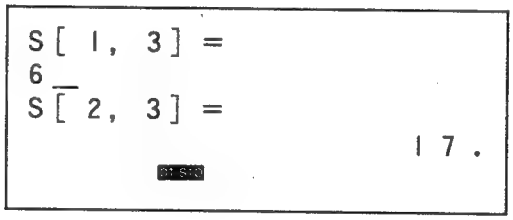
If you need to correct any of the data entered in statistical data input area S, call the data screen in the same manner as you did in the verification of input data and then move the cursor to the position of the data to be corrected by operating the [△] or [▽] key and then enter the correct data followed by depression of the **SET (=)** key.

Example: To correct No.3 data x from 35 to 6

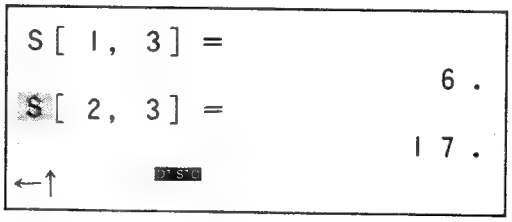
[TITLE DATA] [= SET]



6



[= SET]

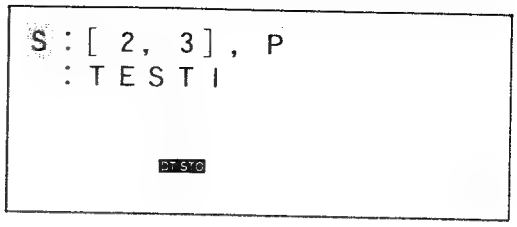


- **Clearing Data from memory S**

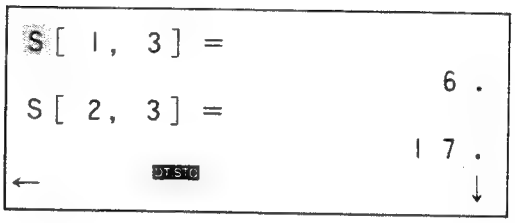
Clearing data one by one

To clear any of the statistical data stored in array variable memory S, press the **DATA (TITLE)** key and then **SET(=)** key. Designate the data to be cleared using the [△] or [▽] key and then press the **CD** key to clear the data.

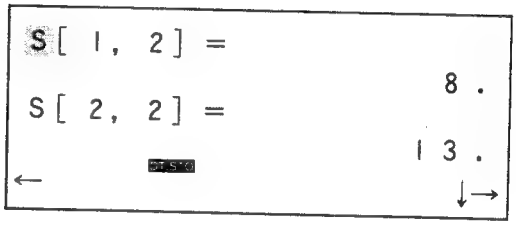
[TITLE DATA]



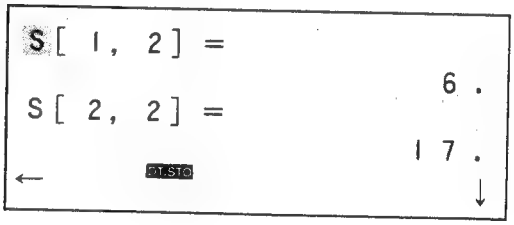
[=SET]



[△] [△]



[CD]



Two-variable data is deleted in pairs (x,y) from memory as shown in the above example.

NOTE: Unless all the data in array variable memory S are cleared by this method, the data array numbers of all the data subsequent to the data cleared are automatically advanced by 1.

Clearing data all at once

To clear all the statistical data stored in array variable memory area S, press the **DATA (TITLE)** key followed by the **2ndF CA** key operation and message "CLEAR? →ENT" will appear in the location of the data title name. Then press the **ENT** key and all the contents of memorys will be cleared.

TITLE DATA

```
S : [ 2, 2] , P
  : T E S T I
```

2ndF CA

```
S : [ 2, 2] , P
  : C L E A R  ? → E N T
```

ENT

```
S : [ 0, 0] , P
  :
```

To return the calculator to the original condition before the "CLEAR? →ENT" message display, press the **CL** key.

• Calculation

Now that you have been oriented to the methods of specifying a data memory area, data input, as well as data verification and correction in the DATA STORE mode, let's practice a two-variable statistical calculation using the following example.

Example: Linear regression

The following table shows two-variable data (marks in math and in English) of six students, respectively. From this data, solve for the coefficients a and b of linear regression $y = a + bx$ and correlation coefficient r. Then estimate the mark in English of a student who would get a mark of 90 for math and the mark in math of a student who would get a mark of 80 for English.

Data title name: TEST

Student No. (n)	Mark in math (Data x)	Mark in English (Data y)
1	82	79
2	53	50
3	61	87
4	74	96
5	51	73
6	51	73

Key in	Your answer	Remarks
• DATA STORE MODE selection		
1		
• Data input		
82 (x, y) 79 DATA		
53 (x, y) 50 DATA		
61 (x, y) 87 DATA		
74 (x, y) 96 DATA		
51 (x, y) 73 × 2 DATA		
2ndF (a)	34.261 9047 6	
2ndF (b)	0.6785714 29	
2ndF (r)	0.5715879 01	
90 2ndF (y')	95.333333333	(estimated mark in Eng.)
80 2ndF (x')	67.403508 77	(estimated mark in Math)
• Data title input		
TITLE DATA ▷ T E S T = SET		

Example: Logarithmic regression
The following table shows two-variable data. From this data, solve for the coefficients a and b of expression $y = a + b \cdot \ln x$ and correlation coefficient r. Then estimate the values of y for the values of x from the logarithmic regression solved with the values of x given as 70 and 250, respectively.

No.	1	2	3	4	5	6
x	5	10	20	40	80	160
y	5.8	9.4	13.0	16.3	18.8	21.1

NOTE: The above expression $y = a + b \cdot \ln x$ can be regarded the same as linear regression $y = a + bx$ if $\ln x$ is substituted by x. Thus, linear regression can be applied to this caluculation.

OPERATIONS IN NONE-STORE MODE

Key in	Your answer	Remarks
2ndF CA ENT 2ndF T▸G▸D		
LN 5 (x, y) 5.8 DATA		
LN 10 (x, y) 9.4 DATA		
LN 20 (x, y) 13 DATA		
LN 40 (x, y) 16.3 DATA		
LN 80 (x, y) 18.8 DATA		
LN 160 (x, y) 21.1 DATA		
2ndF (r)	0.995574251	
2ndF (a)	−0.812425739	
2ndF (b)	4.451744697	
LN 70 2ndF $(\hat{y})$	18.100790433	Estimate when $x = 70$
LN 250 2ndF $(\hat{y})$	23.767708622	Estimate when $x = 250$

Example: Exponential regression
The following table shows two-variable data. From this data, solve for the coefficients a and b of expression $y = a \cdot e^{bx}$ and correlation coefficient r. Then estimate the value of y for the value of x and the value of x for the value of y from the exponential regression solved with the value of x given as 12 and the value of y as 27.4, respectively.

No.	1	2	3	4	5	6
x	2	7	9.2	4.3	5.1	8
y	0.6	4.02	8.3	1.21	2.7	5.1

NOTE: Expression $y = a \cdot e^{bx}$ becomes $\ln y = \ln a + bx$ if the left and right sides of the exponential expression is put in the form of logarithm. The above logarithmic expression can be regarded the same as linear regression $y = a + bx$ if $\ln y$ is substituted by y and $\ln a$ by a. Thus, linear regression can also applied to this calculation.

Key in	Your answer	Remarks
TITLE DATA 2ndF CA ENT		
2ndF T▸G▸D		
2 (x, y) LN .6 DATA		
7 (x, y) LN 4.02 DATA		
9.2 (x, y) LN 8.3 DATA		
4.3 (x, y) LN 1.21 DATA		
5.1 (x, y) LN 2.7 DATA		
8 (x, y) LN 5.1 DATA		
2ndF (r)	0.98350627 7	
2ndF e^x 2ndF (a) =	0.30763283 8	
2ndF (b)	0.36187961 3	
12 2ndF (y')	3.16370706 2	
2ndF e^x 2ndF ANS =	23.65813575	Estimate of y
LN 27.4 2ndF (x')	12.40575911	Estimate of x

• Masking unwanted data

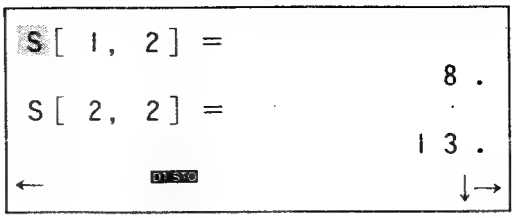
The calculator is provided with a data masking feature which allows you to exclude any unwanted, unusual values existing in the data entered from a calculation in practical statistical data processing, but to retain them as input data.

Call the data screen in the same manner as you did in the verification of input data, and then move the cursor to the position of the data to be masked using the ▽ or △ key, and then operate the **2ndF** and **MASK** keys to mask the data.

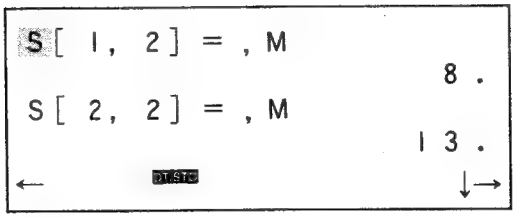
DATA · = SET

```
S[ 1, 3] =
                    35.
S[ 2, 3] =
                    17.
←        PT.STO      ↓
```

△ △



2ndF MASK



The data masked is indicated by symbol " , M" at the right of the equals sign. In case of two-variable data, a set of data x and y will be masked. To release the data from the masked state, press the **2ndF** and **MASK** keys again, and symbol " , M" will disappear.

• Transfer of statistical data

The statistical data stored in array variable memory S can be transferred to another unused array variable memory (for example, to array variable memory A) according to the following procedure.

(1) Set the Mode Selector (slide) switch to the COMP position.
(2) Press the **2ndF** and **MATRIX** to designate the MATRIX mode.
(3) Key in: **MAT** S **STO MAT** A

All the data in array variable memory S are now stored in array variable memory A.

CHAPTER 4
GRAPHICS

The calculator can draw on the 96 × 32-dot LCD, graphs of various intrinsic functions, and graphs of n-th degree algebraic expressions in the COMP mode (except submodes BIN, OCT, HEX, and MATRIX) and statistical graphs in the STAT mode. In addition, the calculator traces, plots, connects with a line, and even enlarges or reduces graphic data on the screen.
Graphs are drawn on a screen dedicated to graphics called the graphics screen.
The contents of the graphics screen remain unchanged when the data clearing operation is performed by pressing the **CL** key, when the calculator's mode is changed by operating the Mode Selector (slide) switch, or when the calculator enters the Auto Power Off state or is turned off by pressing the **OFF** key. The graphics screen can be cleared by operating the **2ndF** and **GCL** keys, **2ndF** and **CA** keys, or the Reset switch.

Range Parameters & Range Setting Screens

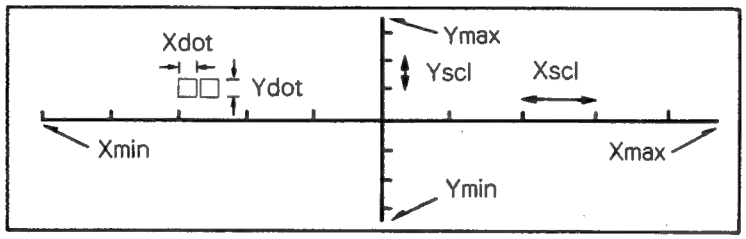
Description of Ranges and Range Parameters

- x-axis range parameters

Xmin — Minimum value of x-axis
Xmax — Maximum value of x-axis
Xscl — Scale pitch of x-axis
Xdot — Dot width in x-axis direction
⊿X — Interval width of statistical graphs (histogram, etc.)

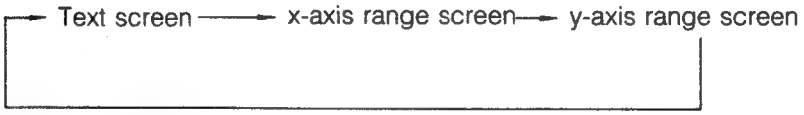
- y-axis range parameters

Ymin — Minimum value of y-axis
Ymax — Maximum value of y-axis
Yscl — Scale pitch of y-axis
Ydot — Dot width in y-axis direction



Range Screens

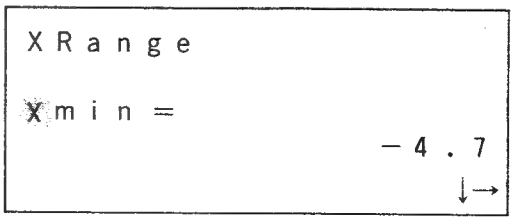
When you press the **RANGE** key for the first time in the COMP or STAT mode, the x-axis range screen is displayed. (In the STAT mode, however, DATA STORE or NON-STORE mode must be selected before pressing the **RANGE** key.) When you press the same key for the second time, the y-axis range screen is displayed.
Pressing the **RANGE** key for the third time causes the display screen to return to the original text screen as illustrated below.



• x-axis range screen

The initial x-axis range screen is as shown below.
The value to be set for the range parameter at the position of the flashing cursor can now be input.

RANGE



To see the value of each x-axis range parameter, press the [▽] key to move the screen up one line, and the value of the next parameter will appear on the screen.
Continue to press the [▽] key to verify the respective x-axis range parameters. However, the value of ⊿X set for any of the statistical graphs (such as histograms, broken-line graphs, etc.) can be verified only in the STAT mode.

[▽]

```
Xmin=
                    -4.7
Xmax=
                     4.8
↑                     ↓→
```

[▽]

```
Xmax=
                     4.8
Xscl=
                     1.
↑                     ↓→
```

[▽]

```
Xscl
                     1.
Xdot=
                    0.1
↑                      →
```

[▽]

```
Xdot=
                    0.1
⊿X=
                     1.
↑                      →
```

• y-axis range screen

Pressing the [▽] key after the confirmation of the value of Xdot (or ⊿X in the STAT mode) causes the display screen to automatically change to the y-axis range screen.
The initial y-axis range screen is as shown below.

[RANGE]

```
YRange
Ymin
                    -1.5
←                     ↓
```

To see the value of each y-axis range parameter, press the [▽] key to move the screen up one line, and the value of the next parameter will appear on the screen.

[▽]

```
Ymin=
                    -1.5
Ymax=
                     1.6
←↑                    ↓
```

[▽]

```
Ymax=
                     1.6
Yscl=
                     0.5
←↑                    ↓
```

[▽]

```
Yscl=
                     0.5
Ydot=
                     0.1
←↑
```

Verification after the range parameter setting can also be made by scrolling the screen up or down with the [▽] or [△] key.

Setting Range Parameters for x- and y-axes

To set the ranges of x- and y-axes in the COMP mode, enter the values of Xmin, Xmax, Xscl, Xdot, Ymin, Ymax, and Yscl, respectively, in the order named. Each value must be entered at the cursor position, followed by depression of the **SET (=)** key.

Example: Setting Xmin as −10, Xmax as 10, Xscl as 2, Ymin as −20, Ymax as 20, and Yscl as 5

[RANGE]

```
XRange
Xmin=
                    -4.7
                      ↓→
```

[(−)] 10 [=/SET]

```
Xmin=
                   -10.
Xmax=
                     4.8
↑                     ↓→
```

10 [=/SET]

```
Xmax=
                    10.
Xscl=
                     1.
↑                     ↓→
```

2 [=/SET]

```
Xscl=
                     2.
Xdot=
  2.10526158E-01
↑                     ↓→
```

NOTE: After the value of Xscl has been input, a value can be input for Xdot. However, when the values of Xmin and Xmax have been input, the value of Xdot is automatically set and thus need not be input. Press the **SET (=)** key and the display screen automatically changes to the y-axis screen.

[=/SET]

```
Y  Range
Ymin=
                    -1.5
←                     ↓
```

[(−)] 20 [=/SET]

```
Ymin=
                   -20.
Ymax=
                    1.6
←↑                    ↓
```

20 [=/SET]

```
Ymax=
                    20.
Ysc l
                    0.5
←↑                    ↓
```

5 [=/SET]

```
Ysc l=
                      5.
Ydot=
          1.2903225801
←↑
```

This completes the setting of all the range parameters for y-axis.

NOTE: 1. If the value of Xmax is arbitrarily set, the value of Xdot will be automatically set by the calculator. Conversely, if the value of Xdot is arbitrarily set, the value of Xmax will be automatically set by the calculator. The same relationship as above exists between Ymax and Ydot. The relationship between Xmax and Xdot and between Ymax and Ydot may be represented by the following formula.

$$Xmax = Xmin + Xdot \times 95$$
$$Ymax = Ymin + Ydot \times 31$$

2. Value to be entered for the range setting must be within the following range.

$$Xmin < Xmax$$
$$Ymin < Ymax$$
$$Xscl > 0$$
$$Yscl > 0$$

$$-10^{100} < Xmin - \frac{Xmax - Xmin}{95},$$

$$Xmax + \frac{Xmax - Xmin}{95} < 10^{100}$$

$$-10^{100} < Ymin - \frac{Ymax - Ymin}{31},$$

$$Ymax + \frac{Ymax - Ymin}{31} < 10^{100}$$

3. If Xmin or Ymin is greater than or equal to Xmax or Ymax, respectively (i.e., max. value ≦ min. value), in the range setting, the first input (maximum or minimum) value will be automatically corrected according to the last input (minimum or maximum) value and the formula shown in Note 1 above. However, if the maximum or minium value automatically corrected exceeds the input value range shown in Note 2 above, an error will result while drawing a graph.
4. If either coordinate axis cannot be displayed on the screen due to the range setting, only the scale is displayed at the left or right part of the display in place of y-axis or at the upper or lower part of the display in place of x-axis.
5. When any value set for the range is changed, the graphic display is cleared and only the coordinate axes based on the changed range are displayed. In this case, the input buffer of the text screen is also cleared.

Resetting Range Parameters

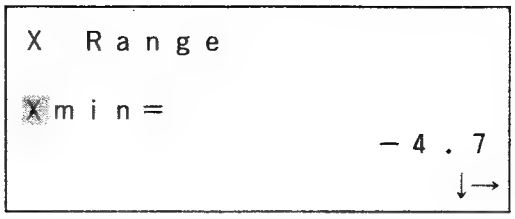
To initialize the range parameters, press the **2ndF** and **CA** keys while each range setting screen is being displayed.

RANGE

```
X  R a n g e

X m i n =
                    - 1 0 .
                          ↓→
```

2ndF CA



The initial value of the respective range parameters are as follows.

Xmin →	−4.7	Ymin →	−1.5
Xmax →	4.8	Ymax →	1.6
Xscl →	1	Yscl →	0.5
Xdot →	0.1	Ydot →	0.1

⊿X → 1 (displayed in STAT mode only)

Graphic Functions in COMP Mode

The graphic functions of this calculator in the COMP Mode (except BIN, OCT, HEX, and MATRIX submodes) are broadly divided into three: Automatic graphing of intrinsic functions, graphing of expressions through manual range setting, and graphing of expressions through automatic y-axis range setting.

Special keys used for graphic functions
All the following keys except the last two are located on the upper part of the right-hand keyboard.

GRAPH
: Graphic Command key
Pressed immediately before the expression to be graphed.
AUTO
: Automatic Y-Range Setting key
Pressed immediately after the expression to be graphed based on the automatically set y-axis range.
DRAW
: Drawing Execution key
Used to execute the drawing of a graph, coordinate point, or line.
RANGE
: Range Screen Select key
Used to call the x-axis and y-axis range screens by rotation.
PLOT
: Plot Command key
Used to display coordinates (points) on the graphics screen.
SOLVE
: Root Solving key
Used to solve for one of more position of intersection (i.e., root) between the graph drawn on the screen and the x-axis.
ZOOM
: Zoom key
Used to enlarge or reduce graphics on the screen at any given scale factor.
2ndF LINE
: Line Drawing key
Used to draw a line between two points on the graphics screen.
2ndF G.CL
: Graphics Clear key
Used to clear all the contents of the graphics screen except x- and y-axes. (This key is on the left-hand keyboard.)
2ndF X⟷Y
: X⟷Y Coordinate Value Selection key
Used to display the value of x and y coordinates by rotation. (This key is on the left-hand keyboards.)

Automatic Graphing of Intrinsic Functions

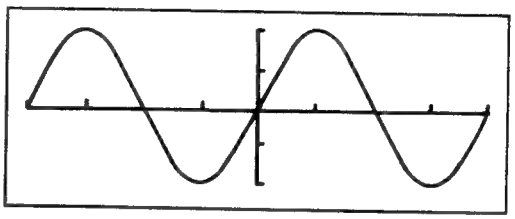
The calculator can automatically draw a graph of any of the following 20 intrinsic functions:

SIN, COS, TAN, SIN^{-1}, COS^{-1}, TAN^{-1}, SINH, COSH, TANH, $SINH^{-1}$, $COSH^{-1}$, $TANH^{-1}$, LOG, LN, 10^x, e^x, $\sqrt{\ }$, $\sqrt[3]{\ }$, x^2, x^{-1}

To automatically draw a graph of an intrinsic function, enter:
GRAPH Intrinsic function **DRAW**

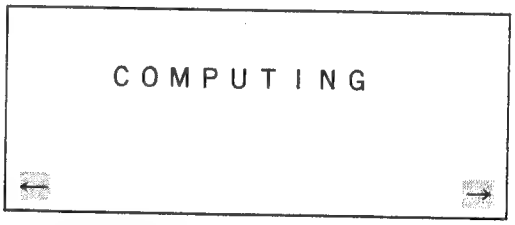
Example: Graph of sine function $y = \sin x$

GRAPH SIN DRAW



When the intrinsic function is executed, the calculator sets the ranges automatically, thus allowing the graph of function to be drawn on the graphics screen after clearing the previous content of the screen.

NOTE: Message "COMPUTING" and flashing " ←" and "→" symbols appear on the display upon pressing the **DRAW** key and continue to be displayed until the calculator starts drawing a graph.



Graph of Expression through Manual Range Setting

With this feature, the calculator draws a graph according to the ranges for x- and y- axes of the graphics screen which you manually set based on the presumption from the expression to be graphed.

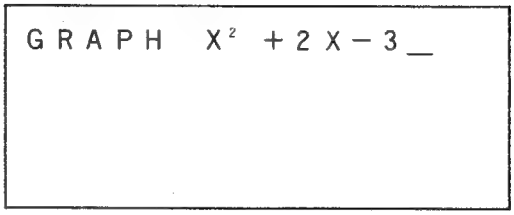
To graph an expression with manual range setting, first set the ranges of the graphics screen and then enter:

GRAPH Expression **DRAW**

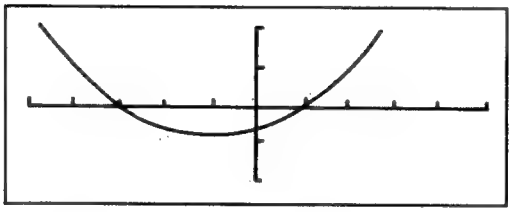
Example:
To graph expression $y = x^2 + 2x - 3$ with manually set range parameters:
Xmin: − 5 Xmax: 5 Xscl: 1
Ymin: −10 Ymax: 10 Yscl: 5

Mode: COMP (→DEC)

[GRAPH] [X] [x^2] [+] 2
[X] [−] 3



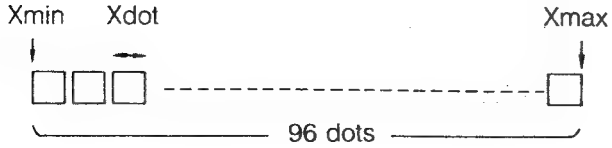
[DRAW]



Upon pressing the **DRAW** key, message "COMPUTING" and flashing "←" and "→" symbols appear on the display and then the calculator starts graphing the expression on the screen.
To verify the expression of the graph just drawn, press the **PB** key to recall the expression or press the **2ndF** and **T▶G▶D** keys to change the screen from Graphics to Text.

Graphing of Expressions through Automatic y-axis Range Setting
With complicated expressions, it is difficult to preset appropriate ranges manually for graphing. The calculator is therefore, provided with an automatic graphing feature which only calls for setting the x-axis range manually and performs the rest of work automatically including the y-axis range setting.

To graph an expression with automatic y-axis range setting, enter:
GRAPH Expression **AUTO** Xmin value [,] Xmax value **DRAW**

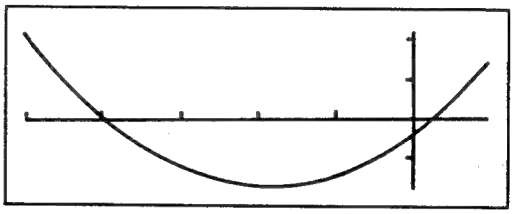


Example: To graph expression $y = x^2 + 6x - 2$ with Xmin set as -8 and Xmax as 1.5.

[GRAPH] [X] [x^2] [+] 6
[X] [−] 2 [AUTO] [(−)] 8
[,] 1.5

```
GRAPH X² +6X−2AUT
0 -8, 1.5_
```

[DRAW]

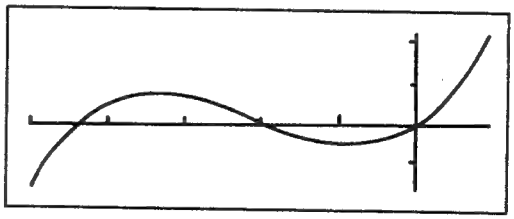


When the values of Xmin and Xmin are not set as in **GRAPH** Expression **AUTO DRAW**, the ranges for y-axis are automatically set according to the Xmin and Xmax values on the range setting screen to draw a graph.

[GRAPH] [X] [Y^x] 3 [+] 10
[X] [x^2] [+] 21 [X]

```
GRAPH XY^x 3+10X²+
21X_
```

[AUTO] [DRAW] (Xmin=−8, Xmax=1.5)



Overwriting of Graphs

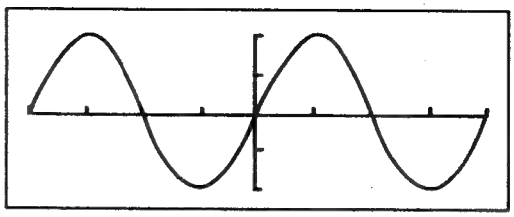
The calculator can draw two or more graphs on the same graphics screen.

• Overwriting of intrinsic function graphs

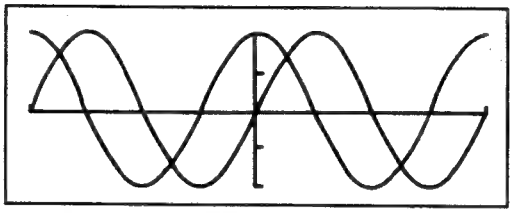
Example:

To write the graph of $y = \cos x$ over the graph of $y = \sin x$

[GRAPH] [SIN] [DRAW]



[GRAPH] [COS] [X] [DRAW]



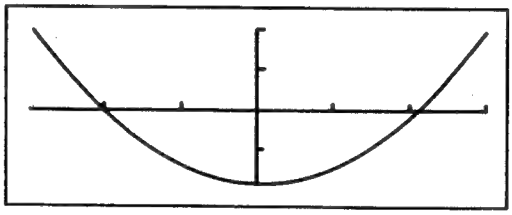
NOTE: In the above example, key operation **GRAPH COS DRAW** (without entry of x after cos) causes the graph of y = sinx to be cleared.

• Overwriting of expression graphs

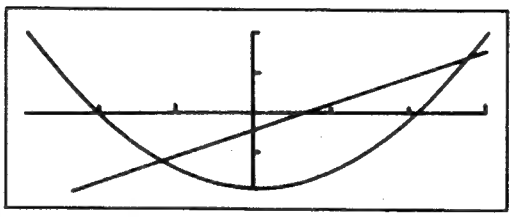
Example:

To draw the graph of $y = x - 0.5$ over the graph of $y = x^2 - 2$ (where $-2 \leq x \leq 2$)

[GRAPH] [X] [x^2] [−] 2
[AUTO] [(−)] 2 [,] 2 [DRAW]



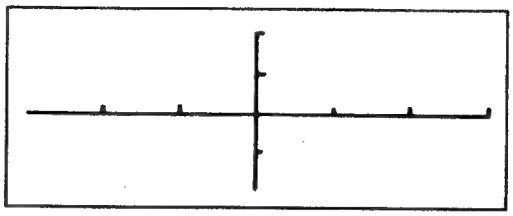
[GRAPH] [X] [−] 0.5 [DRAW]



NOTE: When writing another graph over the graph previously drawn, key operation **GRAPH** Expression **AUTO DRAW** causes the previous graph to be cleared.

If you want to clear the contents of the graphics screen, press the **2ndF** and **G.CL** keys. (In this case, however, the x- and y-coordinate axes will remain displayed.)

[2ndF] [G.CL]



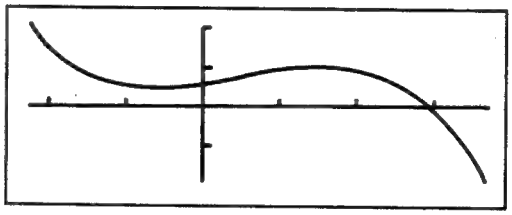
Tracing Function

The calculator is provided with a tracing function which allows you to verify the values of x- and y-coordinates on a graph by moving a coordinate point on the graph in units of dot widths using the [◁] and [▷] keys.

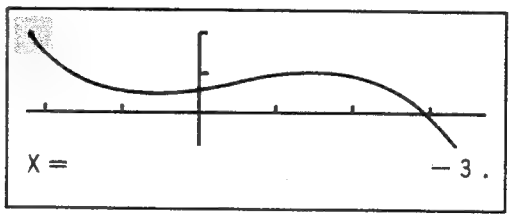
Example:

To draw the graph of expression $y = -x^3 + 2x^2 + 5x + 10$ and then trace the coordinates of the graph (where $-3 \leq x \leq 5$)

[2ndF] [CA] [GRAPH] [(−)]
[X] [Y^x] 3 [+] 2 [X] [x^2]
[+] 5 [X] [+] 10 [AUTO]
[(−)] 3 [,] 5 [DRAW]

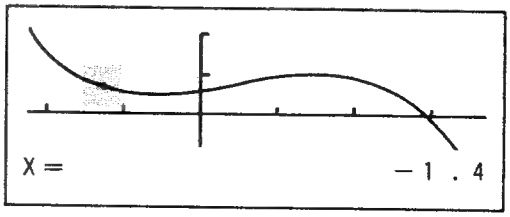


[▷]

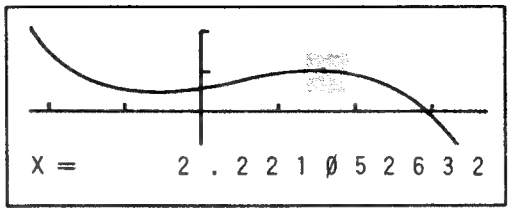


A pointer (i.e., coordinate point) flashes at the left-hand part of the graph when the [▷] key is pressed and at the right-hand part when the [◁] key is pressed. The x coordinate value of the pointer is indicated at the bottom part of the display.

[▷] ··· [▷]



[▷] ··· [▷]



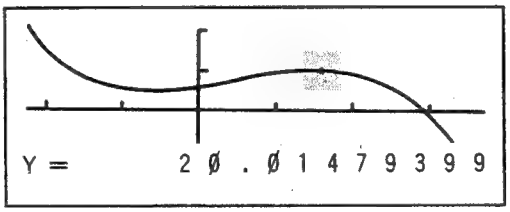
The pointer can be moved in succession by continuously pressing the [◁] or [▷] key.

NOTE: To reverse the tracing direction of the graph from right to left or vice versa, press the cursor key ([▷] or [◁] keys) the opposite direction after confirming that the pointer has been set still.

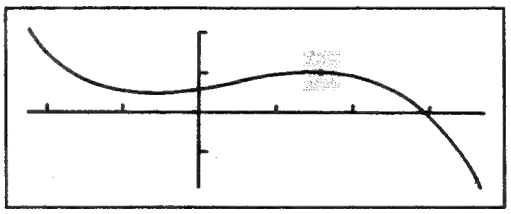
To verify the value of y-coordinate while the value of x-coordinate is being displayed, the **2ndF** and **X⟷Y** keys must be operated. Each time these two keys are pressed, the values of x- and y-coordinates will appear repeatedly in the following sequence.

x-coordinate value indication → y-coordinate value indication → No coordinate value indication →

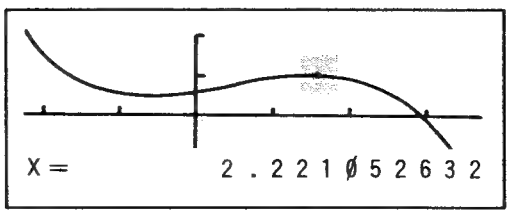
[2 ndF] [X⟷Y]



[2 ndF] [X⟷Y]



[2 ndF] [X⟷Y]



NOTE: 1. To release the tracing function, press the **CL** key. In this case, the graphics screen is cleared and the display returns to the text screen.

2. The coordinate values are displayed at the bottom part of the screen as follows:
   Normal display.....Mantissa: 10 digits
   Scientific notation.....Mantissa: 8 digits plus Exponent: 2 digits
3. The tracing function is effective only while some graph is being drawn on the screen and the expression of the graph still exists in the input buffer.
4. When two or more graphs are on the display (by being overwritten), the last drawn graph is traced with the use of the [▷] and [◁] keys.
5. When a trigonometric function graph drawn on the screen is traced after the unit of angle has been changed with the **2ndF DRG** key operation, the y-coordinate value will not coincide with the graph.

Plotting Function

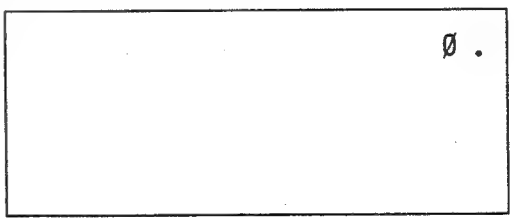
The calculator is provided with a plotting function which displays a point at any coordinate on the graphics screen. The point so displayed can be moved vertically (up and down) and horizontally (left and right) by each of the [△], [▽], [◁], and [▷] keys to allow verification of the coordinate values at the same time.

To plot a coordinate point, enter:

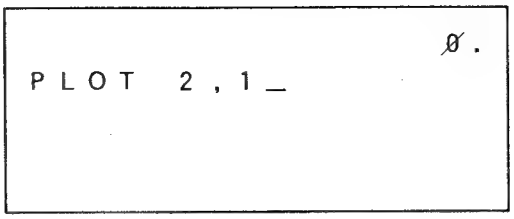
PLOT x-coordinate value [,] y-coordinate value **DRAW**

Example:
To display point (2,1) after initializing the range parameters

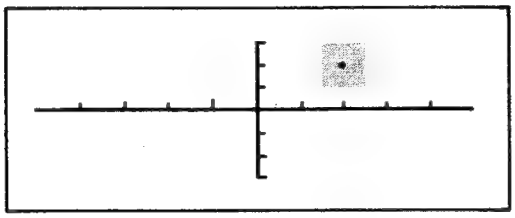
[2ndF] [CA] [RANGE] [2ndF] [CA] [RANGE] [RANGE]



[PLOT] 2 [,] 1

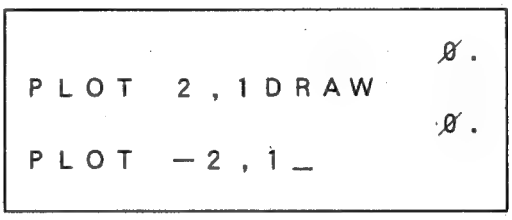


[DRAW]

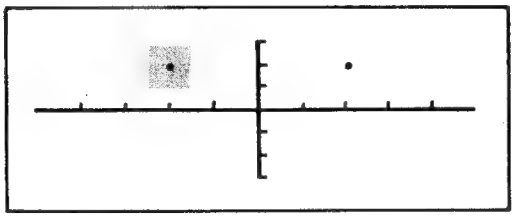


To display point (−2, 1) in succession

[PLOT] [(−)] 2 [,] 1



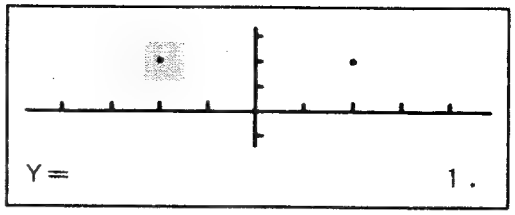
[DRAW]



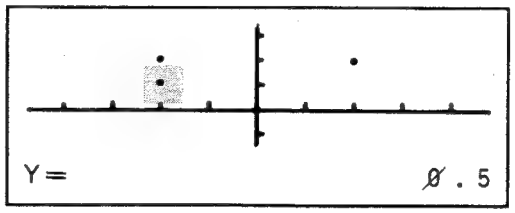
Once you have displayed a coordinate point on the screen with the **PLOT** key, the 2nd and 3rd points can be displayed on the same screen without using the **PLOT** key for displaying each point. To do so, move the pointer to any desired point using the [▷], [◁], [▽], or [△] key and press the **DRAW** key alone and the point will be displayed on the screen.

To display point (−2, 0.5) in succession, display the y-coordinate value by operating the **2ndF** and **X⟷Y** keys and press the **DRAW** key when the value of y-coordinate is 0.5.

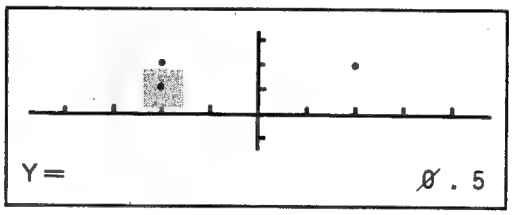
2 ndF X↔Y 2 ndF X↔Y



▽ ··· ▽

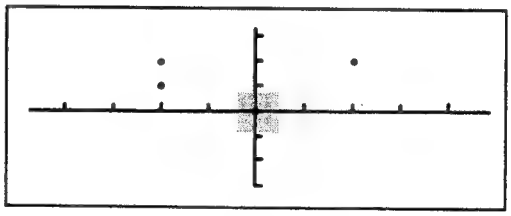


DRAW



The point (−2, 0.5) is plotted on the screen with the **DRAW** key. The point just drawn continuous to flash until another coordinate point is specified.

PLOT DRAW



When the values of x- and y- coordinates are not set (i.e., when only **PLOT** and **DRAW** keys are operated), a pointer flashes at the center point of the screen.

Line Drawing Function

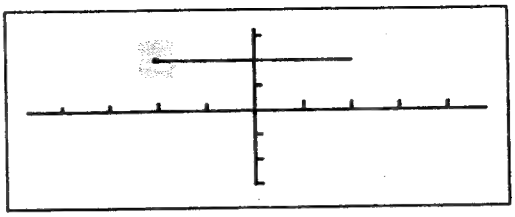
The calculator can connect two points being displayed on the screen with a line.

To draw a line between one point (x_1, y_1) and the other point (x_2, y_2), enter:

2ndF LINE x_1 [,] y_1 [,] x_2 [,] y_2 [,] **DRAW**

Example:
To draw a line between points (2,1) and (−2, 1)

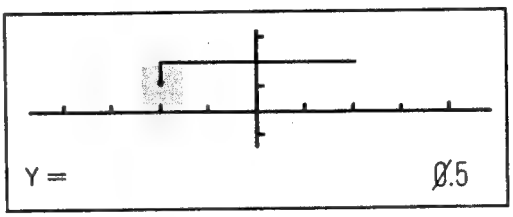
[RANGE] [2 ndF] [CA] [RANGE]
[RANGE] [2 ndF] [LINE] 2 [,]
1 [,] [(−)] 2 [,] 1 [DRAW]



Once you have drawn a line with the **2ndF LINE** key operation, you can connect the line to other points in succession without using the **2ndF LINE** for connection to each point. To do so, move the pointer to any desired point using the [▷], [◁], [△], or [▽] key and press the **DRAW** key alone and the line will be extended to the specified point.

To connect points (−2, 1) and (−2, 0.5) with a line in succession, display y-coordinate values by operating the **2ndF** and **X↔Y** keys and press the **DRAW** key when the value of the y-coordinate is 0.5.

[▽] ..... [▽] [DRAW]

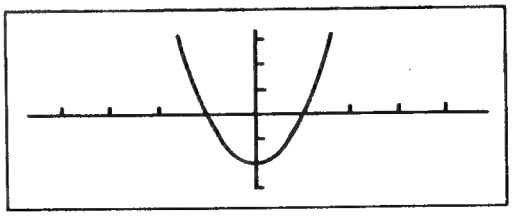


NOTE: When the tracing, plotting, or line drawing function is executed, the x- and y-coordinate values are stored in the X and Y memories, respectively.

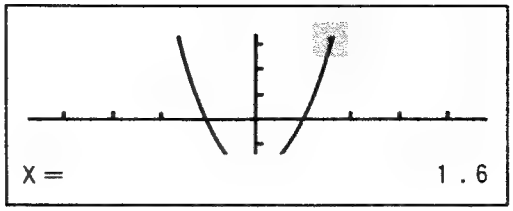
Scrolling Function
Using the tracing function of the calculator, the graphics screen may be scrolled row by row (from top to bottom or bottom to top) and column by column (from left to right or right to left) to allow reviewing of graphic data that exists on a virtual screen (i.e., outside the actual 96 × 32-dot LCD display).

Example: To scroll the screen to review a graph of $y = x^2 - 1$ (with range parameters initialized)

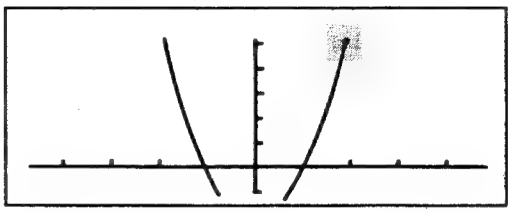
[RANGE] [2ndF] [CA] [RANGE]
[RANGE] [GRAPH] [X] [x^2]
[−] 1 [DRAW]



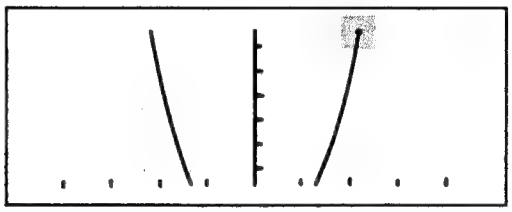
◁



2ndF X⟷Y 2ndF X⟷Y
▷ ..... ▷



▷ ..... ▷



Graphics Enlarging/Reducing Function

The calculator is capable of enlarging or reducing the range parameters of the graphics screen by centering on the flashing coordinate point using the plotting or tracing function.

Enlargement .....Multiplies the minimum and maximum values of x- or y-axis range by 1/n
Reduction .....Multiplies the minimum and maximum values of x- or y-axis range by n

Enlargement or reduction can be executed by the following key operations with the flashing coordinate point centered on.
To enlarge or reduce a grah in both the x- and y-axis directions at the same scale factor, enter:

AUTO scale factor **ZOOM**

To enlarge or reduce a graph by m times in the x-axis direction and by n times in the y-axis direction, enter:

AUTO m [,] n **ZOOM**

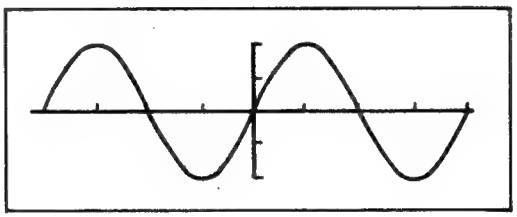
The calculator executes enlargement if the scale factor is greater than 1 and reduction if the scale factor is less than 1. If the scale factor is 1, the minimum and maximum values of x-or y-axis range remain unchanged.

When either of the above key operations is performed without flashing coordinate point on the screen, the calculator executes enlargement or reduction automatically with the center of the screen taken as a reference point.

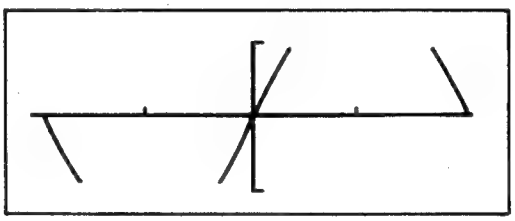
Once a scale factor has been set followed by depression of the **ZOOM** key, enlargement or reduction may be executed continuously at the same scale factor by merely pressing the **ZOOM** key.

Example 1:
To enlarge the graph of y=sinx at a scale factor of 2 in x- and y- axis directions (with the center of the screen taken as a reference point)

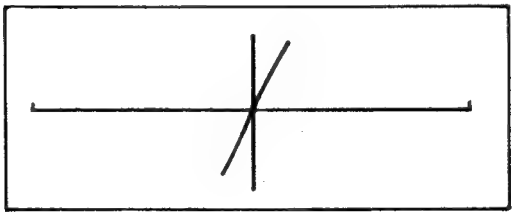
[GRAPH] [SIN] [DRAW]



[AUTO] 2 [ZOOM]

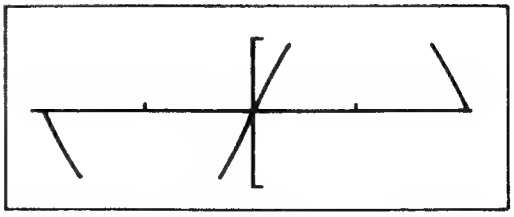


[ZOOM]

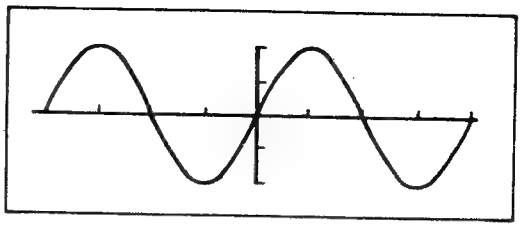


To reduce the same graph in the same directions at a scale factor of 1/2

[AUTO] 0.5 [ZOOM]

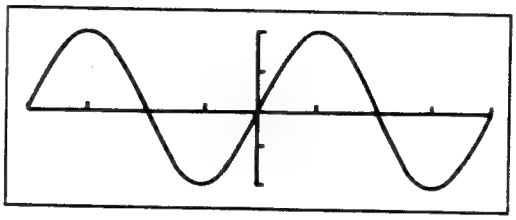


ZOOM

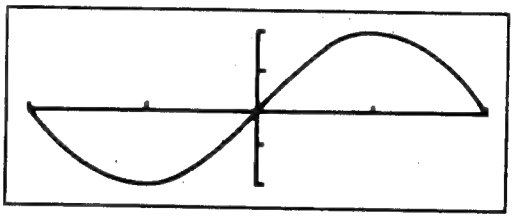


To enlarge the same graph in the x-axis direction only at a scale factor of 2

GRAPH SIN DRAW

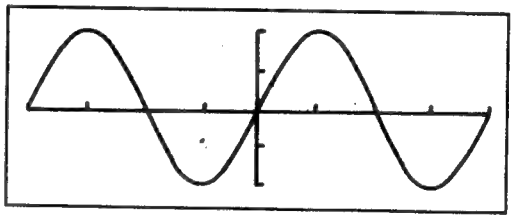


AUTO 2 , 1 ZOOM



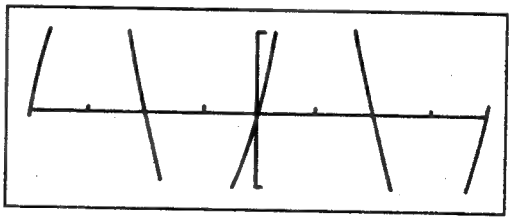
To reduce the same graph in the x-axis direction only at a scale factor of 1/2

AUTO 0.5 , 1 ZOOM



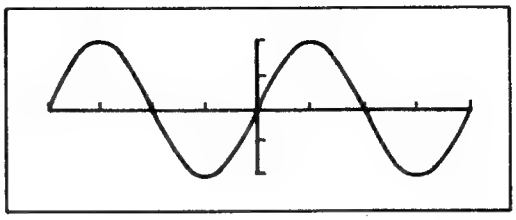
To enlarge the same graph in the y-axis direction only at a scale factor of 2

AUTO 1 , 2 ZOOM



To reduce the same graph in the y-axis direction only at a scale factor of 1/2

[AUTO] 1 [,] 0.5 [ZOOM]



NOTE: To enlarge or reduce a graph drawn with **GRAPH** expression **AUTO** Xmin [,] Xmax **DRAW** (i.e., a graph drawn with automatic scaling), first call the expression of the graph on the text screen with the **PB** key and delete the **AUTO** Xmin [,] Xmax part immediately after the expression with the **DEL** key, and then enter:
AUTO scale factor **ZOOM**
Without releasing the AUTO command for the graph of the expression, operation of **AUTO** scale factor **ZOOM** immediately after drawing the graph will not cause the graph to be neither enlarged nor reduced.

Root Solving Function

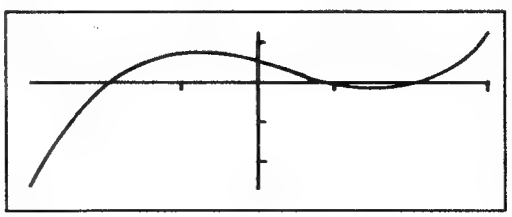
With this function, the calculator can solve for point(s) of intersection between a graph drawn with the **DRAW** key and the x-axis.

PROCEDURE

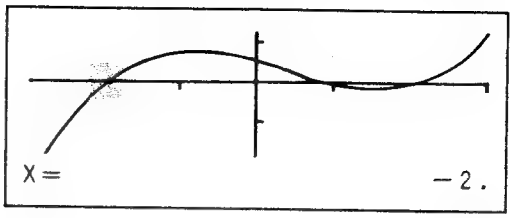
1. Draw a graph of an expression, for which one or more roots are to be solved for.
2. Verify on the graphics screen that the graph has a point of intersection with the x-axis.
3. Press the **SOLVE** key and message "COMPUTING" will appear and a point (i.e., root) at which the graph intersects the x-axis at its leftmost part will be indicated on the display. At the same time, a pointer will flash at the point of intersection.
4. Press the **SOLVE** key again if another point of intersection (root) exists, and the next point of intersection on the right-hand part of the x-axis will be automatically displayed and the flashing pointer will move to that point of intersection.

Example: To solve for roots of $y = x^3 - x^2 - 4x + 4$ (where $-3 \leq x \leq 3$)

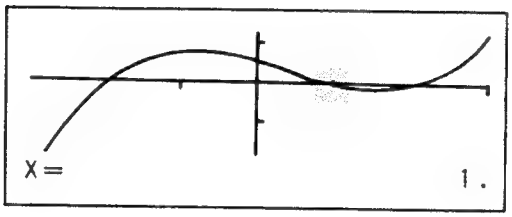
[GRAPH] [X] [Y^x] 3 [−] [X]
[x^2] [−] 4 [X] [+] 4
[AUTO] [(−)] 3 [,] 3 [DRAW]



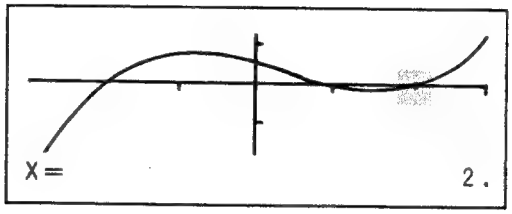
SOLVE



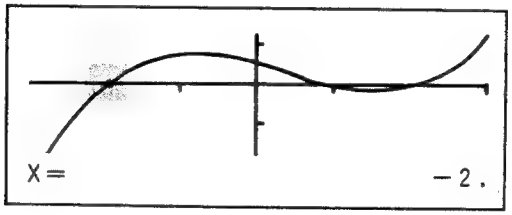
SOLVE



SOLVE



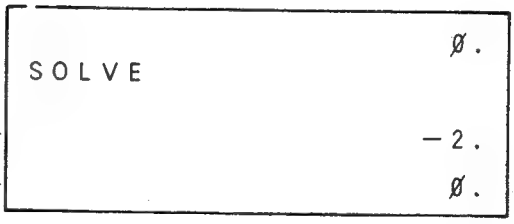
SOLVE



2ndF T▶G▶D 2ndF T▶G▶D

x-coordinate at point of intersection→

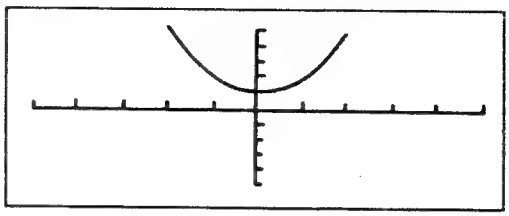
y-coordinate at point of intersection→



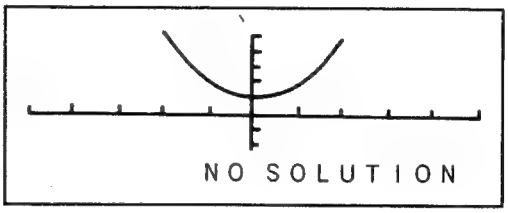
The x- and y-coordinate values (approximate values) at the point of intersection are displayed on the text screen.

Example:
To solve for roots of $y=x^2+1$ with Xmin set to−5, Xmax to 5, Ymin to −5, Ymax to 5 and Yscl to 1 (but no root exists).

[GRAPH] [X] [x^2] [+] 1
[DRAW]



[SOLVE]



NOTE:

1. Operation of the **SOLVE** key in the absence of any other root causes message "NO SOLUTION" to be displayed.
2. If the x-axis is tangent to the graph, solve for the approximate value of the point of contact using the trace function. Operation of the **SOLVE** key, in this case, will result in display of message "NO SOLUTION".
3. The root solving function is effective only when expression(s) of which root(s) are to be solved for exist in the calculator's input buffer memory.
4. This function solves for one or more points of intersection existing within the range of Xmin to Xmax. Press the **SOLVE** key after the last point of intersection (at the right-hand part of x-axis) has been solved for and the pointer will return to the first point of intersection at the leftmost part of the graph.
5. This function solves for points of intersection with respect to continuous functions which intersect the x-axis. If you attempt to solve for points of intersection for discontinuous functions (INT, etc.), the correct solution may not be obtained. Errors in calculation may occur because x- and y-coordinate values are calculated by approximation.
6. When two or more graphs are on the display (by being overwritten), the points of intersection at which the x-axis intersects the last drawn graph will be solved for by the **SOLVE** key operation.

Graphics Functions in STAT Mode

In the STAT mode, the calculator can draw six different kinds of statistical graphs to allow your review of the trend of the statistical data entered.

Drawing Statistical Graphs

• Types of statistical graphs and graphics command keys

The following six keys are located on the upper part of the right-hand keyboard to allow output of the respective types of statistical graphs on the graphics screen.

2ndF G(HI): Histogram (bar graph)

2ndF G(BL): Broken-Line graph

2ndF G(CF): Cumulative Frequency graph

2ndF G(ND): Normal Distribution graph

2ndF G(SD): Scatter Diagram (with two-variable data only)

2ndF G(LR): Linear Regression (with two-variable data only)

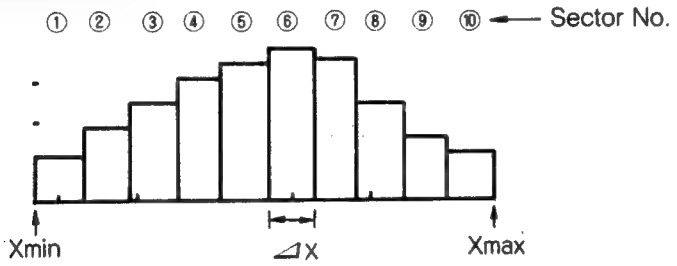
Statistical graphs can be drawn in either of the DATA STORE and NON-STORE modes. In both modes, drawing a graph may be executed while you input statistical data. In the NON-STORE mode, however, statistical data entered may be erased if you change the range setting of the graphics screen.

NOTE: In the STAT mode, general expressions may be drawn on the screen just the same as in the COMP mode.

In this section, drawing statistical graphs are explained using the following data entered in the DATA STORE mode.

Data No.	Mark	No.of students	Data No.	Mark	No. of students
1	10	9	6	60	31
2	20	15	7	70	29
3	30	20	8	80	20
4	40	25	9	90	13
5	50	28	10	100	10

• Histogram (bar graph)



(1) Drawing a histogram with single-variable data in DATA STORE mode
You may use any of the following three methods to output a histogram on the graphics screen.

(a) [2 ndF] [G(HI)] [AUTO] [DRAW]
In this operation, all the range parameters related to the histogram are automatically set by the calculator.

* Xmin, Xmax – Of all the statistical data input, minimum and maximum values are automatically determined by the calculator and set as Xmin and Xmax, respectively.
* Number of sectors – Automatically set to 10.
* ⊿X – The value of (Xmax – Xmin + Xdot) ÷ 10 are automatically set.
* Ymin – Automatically set to 0.
* Ymax – Automatically set to Ymax = 31 if the maximum frequency value does not exceed 31 (1 dot = 1 frequency), or to Ymax = maximum frequency value if it exceeds 31.
* The contents of the range setting screen are changed automatically.

(b) [2 ndF] [G(HI)] [AUTO] Xmin [,] Xmax [,] ⊿X [DRAW]
In this operation, the values of Xmin, Xmax, and ⊿X must be entered manually as the x-axis range of the histogram and the y-axis range parameters are automatically set to their respective default values as described in (a) above. However, if you fail to specify any of Xmin, Xmax, and ⊿X, the parameter omitted is automatically set to its default value as described in (a) above.

NOTE: The maximum number of sectors permissible for a histogram is 32. If the number of sectors is set in excess of this value, an error will result.

(c) [2 ndF] [G(HI)] [DRAW]
By this operation, the calculator draws a histogram according to the contents of the range setting screen.

(2) Drawing a histogram with two-variable data in DATA STORE mode
A histogram related to data x can be drawn by the same key operation as that described in (1) above for a histogram with single-variable data.
A histogram related to data y can be drawn by first operating the **2ndF** and **G(HI)** keys and then the **2ndF** and **X⟷Y** keys. The rest of the procedure is the same as when drawing a histogram with single-variable data.

Example:

[2 ndF] [G(HI)] [AUTO] [DRAW] (for data x)

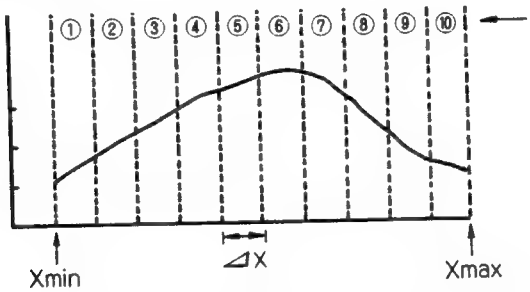
[2 ndF] [G(HI)] [2 ndF] [X⟷Y] [AUTO] [DRAW] (for data y)

(3) Drawing a histogram in NON-STORE mode

[2 ndF] [G(HI)] [DRAW]

This key operation causes a histogram to be drawn according to the contents of the range setting screens.

- **Broken-line graph**



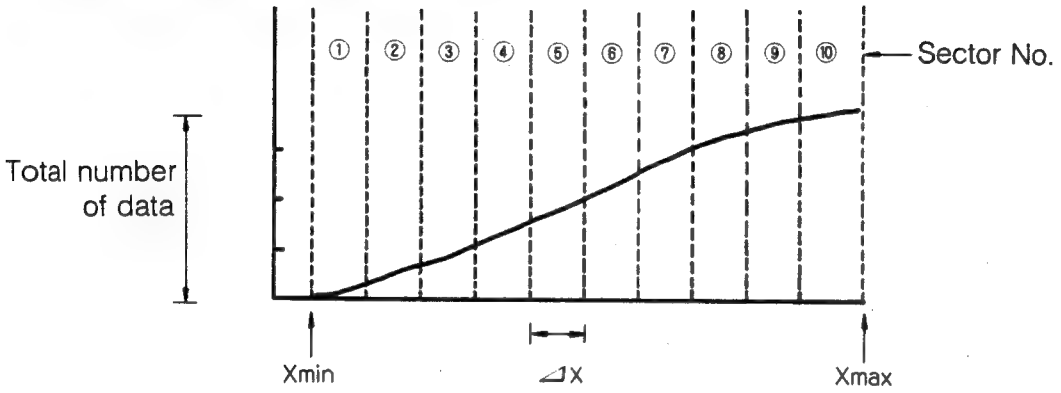
(1) Drawing a broken-line graph in DATA STORE mode
The key operation for drawing a graph of broken lines with single-variable or two-variable data in the DATA STORE mode is the same as that for drawing a histogram in the DATA STORE mode, except that the **2ndF** and **G(BL)** keys are used in place of the **2ndF** and **G(HI)** keys.
Example: [2 ndF] [G(BL)] [AUTO] [DRAW]

(2) Drawing a broken-line graph in NON-STORE mode

[2ndF] [G(BL)] [DRAW]

This key operation causes a broken-line graph to be drawn according to the contens of the range setting screens.

- **Cumulative frequency graph**



(1) Drawing a cumulative frequency graph in DATA STORE mode
The key operation for drawing a cumulative frequency graph with single-variable or two-variable data in the DATA STORE mode is the same as that for drawing a histogram in the DATA STORE mode, except that the **2ndF** and **G(CF)** keys are used in place of the **2ndF** and **G(HI)** keys, and that the calculator will automatically set the value of Ymax to the total number of data n.

The above frequency graph can be drawn on the screen with the following key operation:

[2ndF] [G.CL] [2ndF] [G(CF)] [AUTO] [DRAW]

Example: [2ndF] [G(CF)] [AUTO] Xmin [,] Xmax [,] ⊿X [DRAW]

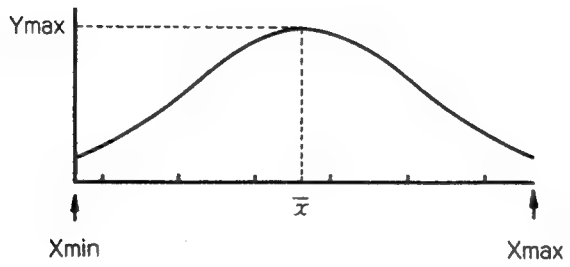
(2) Drawing a cumulative frequency graph in NON-STORE mode

[2ndF] [G(CF)] [DRAW]

This key operation causes a cumulative frequency graph to be drawn according to the contents of the range setting screens.

When the **2ndF G(CF) AUTO DRAW** key operation is performed, a cumulative fuquency graph is drawn over the graph that has already been drawn on the graph. In this case, the calculator will automatically set the value of Ymax to 100%. Therefore, this key operation can be used to draw a cumulative frequency graph over a histogram or broken-line graph.

- **Normal distribution graph**



(1) Drawing a normal distribution graph in DATA STORE mode
The key operation for drawing a normal distribution graph with single-variable or two-variable data in the DATA STORE mode is the same as that for drawing a cumulative frequency graph, except that the **2ndF** and **G(ND)** keys are used in place of the **2ndF** and **G(CF)** keys. The above distribution graph can be drawn on the screen with the following key operation:

[2ndF] [G.CL] [2ndF] [G(ND)] [AUTO] [DRAW]

Example: [2ndF] [G(ND)] [AUTO] Xmin [,] Xmax [,] ⊿X [DRAW]

NOTE: When the **2ndF G(ND) AUTO DRAW** key operation is performed, a normal distribution graph is drawn over the graph that has already been drawn on the screen. In this case, the calculator will automatically set the value of Ymax to the y-coordinate value of normal distribution $X=\bar{x}$ (mean value). Therefore, this key operation can be used to draw a normal distribution graph over a histograph or broken-line graph.

(2) Drawing a normal distribution graph in NON-STORE mode

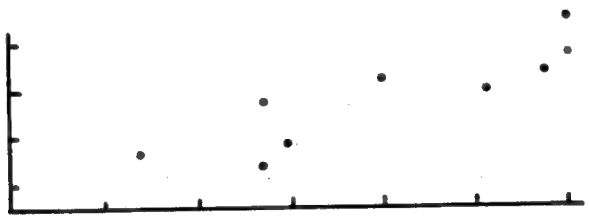
[2ndF] [G(ND)] [DRAW]

This key operation causes a normal distribution graph to be drawn according to the contents of the range setting screens.

- **Scatter diagram**

This function works only with two-variable statistical data. The calculator uses input data as coordinates without any change and plots them on the graphics screen. Here, the following two-variable data will be used to output a scatter diagram on the screen.

NO.	1	2	3	4	5	6	7	8	9	10
x	1.4	2.0	2.6	2.6	2.7	3.2	3.7	4.0	4.1	4.1
y	65	76	90	74	80	95	92	97	102	110



(1) Drawing a scatter diagram in DATA STORE mode
Enter all the data in the above table.
You may use either of the following two methods to output a scatter diagram on the graphics screen.

(a) [2 ndF] [G(SD)] [AUTO] [DRAW]

Of all data x entered, minimum and maximum values are automatically determined and set as Xmin and Xmax, Ymin, Ymax, respectively.In this case, the contents of the range setting screen are automatically changed.

(b) [2 ndF] [G(SD)] [DRAW]

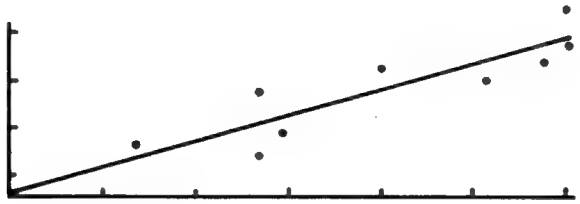
With this key sequence, the calculator draws a scatter diagram according to the contents of the range setting screen. In this case, however, any of data x and y entered is greater than the value of Xmax or Ymax or less than the value of Xmin or Ymin, such data will not be plotted.

(2) Drawing a scatter diagram in NON-STORE mode
(a) Set the x- and y-axis range parameters to arbitrary values.
(b) The key operation **2ndF G(SD) DRAW** will put the calculator in the ready state for drawing a scatter diagram.

(c) Each time data is entered, the coordinate of the data entered is displayed on the graphics screen according to the contents of the range setting screen.

• Linear regression

The linear regression is automatically determined and plotted on the graphics screen, based on the two-variable data entered.



(1) Graphing linear regression in DATA STORE mode

The key operation for graphing the linear regression is the same as that for drawing a scatter diagram, except that the **2ndF** and **G(LR)** keys are used in place of the **2ndF** and **G(SD)** keys.

Example: [2 ndF] [G(LR)] [AUTO] [DRAW]

The above graph is drawn with this key operation. When the **AUTO** key is used before the **DRAW** key, the calculator clears the contents of the screen and draws only the linear regression. Operate the **2ndF G(LR) DRAW** keys without use of the **AUTO** key after drawing a scatter diagram, to draw the linear regression over the scatter diagram.

(2) Graphing linear regression in NON-STORE mode

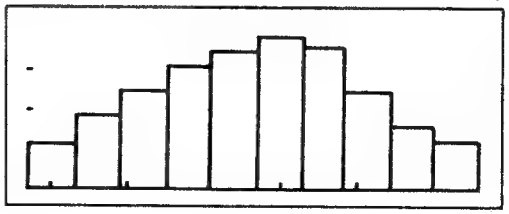
[2 ndF] [G(LR)] [DRAW]

This key operation causes the linear regression to be graphed according to the contents of the range setting screen.

Tracing Statistical Graphs

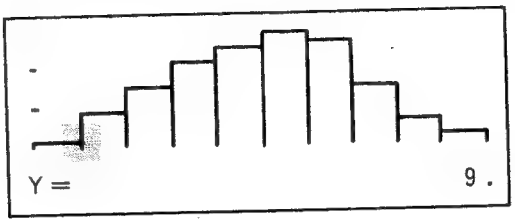
The calculator is capable of tracing with the [◁] or [▷] key after a histogram, broken-line graph, or cumulative frequency graph has been drawn.

•Histogram



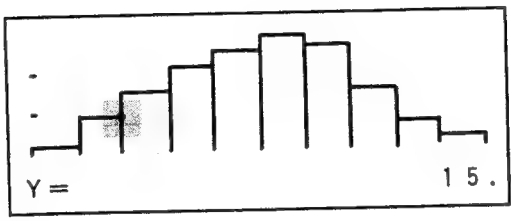
NOTE: The pointer appears at the right of the histogram and thus the position of the pointer does not coincide with its x-coordinat value.

▷

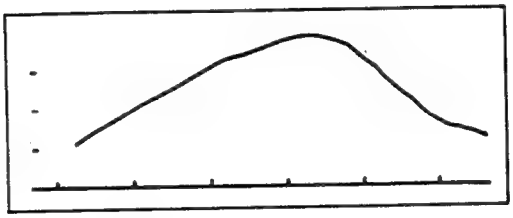


← Frequency display

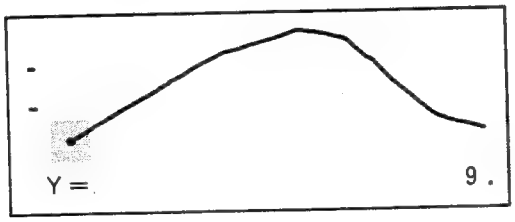
▷



• Broken-line graph



▷

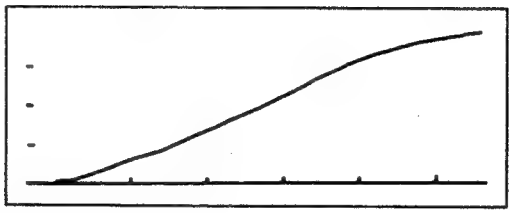


← Frequency display

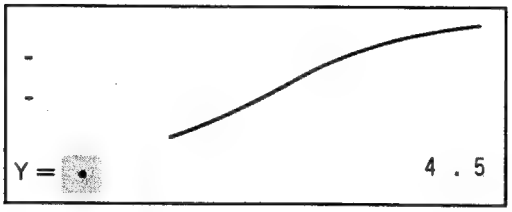
▷

• Cumulative frequency graph

A cumulative frequency is displayed just the same as with the graph of broken lines shown above.

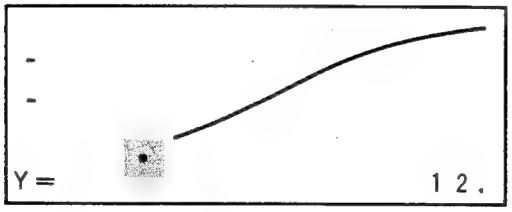


[▷]



←Frequency display

[▷]



CHAPTER 5

OPERATIONS IN AER-I & AER-II MODES

The calculator is provided with a function called the Algebraic Expression Reserve (AER), which is, in essence, a programming function and is convenient for repetitive calculations. This function allows you to preprogram calculation procedures (i.e., algebraic expressions) into the calculator in the AER-I or AER-II mode so that the calculator may automatically execute calculations on numbers or variables which you will enter in the COMP mode. The calculator has a programming capacity of 5,120 steps (or 5,120 bytes) for storing programs consisting mainly of algebraic expressions and mathematical formulas, though these bytes may be shared for statistical data and array variables. In addition, the calculator can perform conditional expression judgment and looping functions.

How to Use AER Function

Modes and Programming Formats

Depending on the format of an algebraic expression or mathematical formula you wish to program, the Mode Selector switch must be set to either the AER-I or AER-II position.

• AER-I mode

This mode is used exclusively for writing an algebraic expression (program) which uses store memories A through Z and memories for array variables A [ ] through Z [ ] as the variables of the expression, and does not allow use of any lowercase letters, Greek letters, other special characters, and number reduced in size as variables.

(1) Variable designation

Variables in an expression must be designated in the form shown below.

[f()=/?] store memories (or array variable) [f()=/?]

(2) Basic formats of algebraic expressions

(a) f(A~Z) = [Expression] Example: f (AB) = $A^2 + B^2$

(b) [Expression] ⇒ [Memory] Example: $A^2 + B^2 \Rightarrow C$

(c) [Expression] Example: $A^2 + B^2$

• AER-II mode

This mode is used exclusively for writing an algebraic expression (program) which uses a combination of lowercase letters, Greek letters (α β, γ, θ, etc.), other special characters (/, , &, etc.), and numeric characters reduced in size as the variables of the expression, in addition to store memories A through Z and array variable memories A [ ] through Z [ ].

(1) Variable designation

The calculator automatically regards lowercase letters, special characters such as Greek letters and other symbols, and numeric characters reduced in size, as variables in an expression. The designation of variables is therefore not required when using these characters.

In the AER-II mode, the [f()=/?] key is also used as the Variable Input Command (and thus "=?" is input in the program being written).

(2) Basic formats of algebraic expression

(a) [Memory] = [Expression] Example: a = b + c, A = B + C

(b) [Expression] Example: $b^2 + c^2$

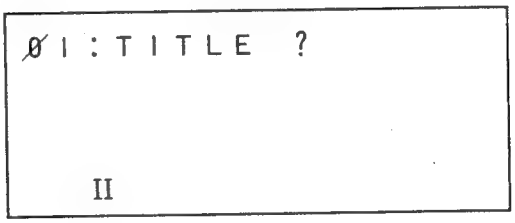
Configuration of Algebraic Expression (Program)

An algebraic expression (or a program) consists of a title and a main routine with or without one or more subroutines.

Title number				
01:	Title	main routine	subroutine 1 ... 9.0	
02:	"	"	"	"
:	:	:	:	:
99:	Title	main routine	subroutine 1 ... 9.0	

(1) Program title
To store a program, first type in the program title name.

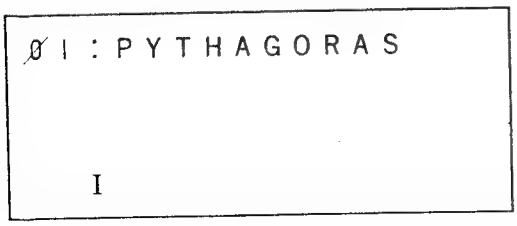
• When you slide the Mode Selector switch to the AER-I or AER-II position, a message: "Ø1:TITLE?" will appear in the display to prompt you to enter the title of your program.



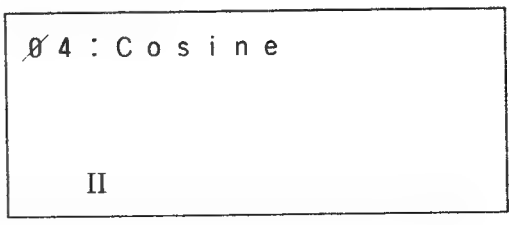
The calculator numbers all programs consecutively in two digits (01~99) in the order of their input irrespective of the AER-I or AER-II mode, and displays the title number to the left of the "TITLE?" message.

Example:

AER-I mode



AER-II mode



• Up to 61 characters may be used for a single program title. Any characters entered in excess of this capacity are regarded as the character entered in the 61st position and cause the character previously entered at that position to be rewritten.

• Pressing the **ENT** key following the entry of title characters causes the program title to be stored in memory and message "M:" to appear. If you press the **ENT** key without entering a program title, the message "M:" appears in the display.

You may program a maximum of 99 algebraic expressions in both the AER-I and AER-II modes within the memory capacity of the calculator.
If you press the **ENT** key without entering a main routine, the message "TITLE?" reappears in the display.

(2) Main routine
• When you press the **ENT** key to store the program title, "M:" will appear in the display. This indicator "M" informs you that you are going to store a main routine. (The first program line immediately after a program title is automatically assigned to a main routine.)

(3) Subroutine(s)
• In a series of calculation procedures, if you have an expression to be used over and over again, it is advisable to write the expression as a subroutine and call it in the main routine for execution as the occasion calls for. In this way, you can simplify the calculation procedures.

• If you wish to use a subroutine in a program, press the **2ndF** and **SUB:** keys after typing in the main routine. The main routine is stored in memory and " 1 :" indicator appears in the display to prompt you to enter the subroutine. The indicator " 1 :" is the label number of your first subroutine. You can program a maximum of 10 subroutines per main routine.
The calculator sequentially labels all the subroutines to be stored with numbers 1 through 9 and 0 at the beginning of each subroutine line.

• You cannot call another subroutine within a subroutine.

• If your main routine has no subroutine, press the **ENT** key after typing in the main routine. Message "TITLE?" will appear in the display. You may now enter the next new program.

NOTE: 1. The maximum length of an expression that you can write in one program line is 160 steps. Any characters and symbols entered in excess of this capacity are regarded as the 160th step and cause the character or symbol previously entered at that step to be rewritten. So, be sure to program each of your expressions within the capacity of 160 steps per line. If this is not possible, use sub-routines.

2. Remember that in the STAT mode as well as in the BIN, OCT, HEX, and MATRIX submodes of the COMP mode, the calculator cannot execute any of the programs you wrote in the AER-I or AER-II mode.

Keys Used for Programming

The following keys are used to write programs:

(1) AER-I mode

0 ~ **9**: Numeric entry (0 through 9)

A ~ **Z**: Alphabetic entry in uppercase letters (A through Z)

2ndF 0 ~ **2ndF 9**: Subroutine label entry (1 through 9 and 0)

(2) AER-II mode

0 ~ **9**: Numeric entry (0 through 9)

A ~ **Z**: Alphabetic entry in lowercase letters (a through z)

SHIFT A ~ **SHIFT Z**: Alphabetic entry in uppercase letters (A through Z)

SHIFT 0 ~ **SHIFT 9**: Numeric entry (numeric characters 0 through 9 reduced in size)

2ndF 0 ~ **2ndF 9**: Subroutine label entry (1 through 9 and 0)

2ndF SYMBOL: Special character selection (See Special Character Selection below.)

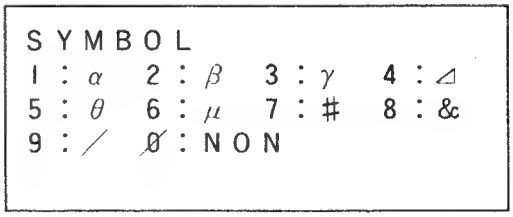
Special Character Selection

The calculator accepts nine different special characters for programming in the AER-II mode.

Operation of the **2ndF** and **SYMBOL** keys causes a screen to appear for selection of special characters.

Screen for special character selection

[2ndF] [SYMBOL]



When the desired special character is selected by pressing one of the numeric **1** through **9** keys, the display automatically returns to the screen immediately before pressing the **2ndF** and **SYMBOL** keys and the selected character is entered at the cursor position.
When the **2ndF** and **SYMBOL** keys are pressed without selecting any special character or when numeric **0** is pressed, the display returns to the original screen.

Example of special character input operation

To enter "Data (5/14)" as the title:


```
I Ø : T I T L E   ?


   II
```

[SHIFT] [D] [A] [T] [A]
[␣] [(] 5

```
I Ø : D a t a   ( 5 _


   II
```

Use the [␣] key to enter space.

[2ndF] [SYMBOL]

```
S Y M B O L
1 : α  2 : β  3 : γ  4 : ⊿
5 : θ  6 : μ  7 : #  8 : &
9 : ⁄  Ø : N O N
```

9

```
I Ø : D a t a   ( 5 ⁄ _


   II
```

14 [ )]

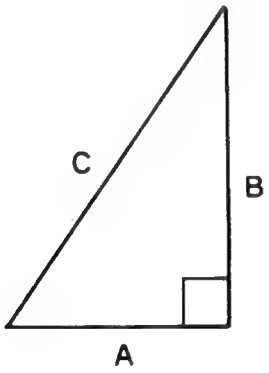
```
10: Data  (5/14) _

II
```

Programming Examples

Example 1: Pythagorean Theorem Program

To solve for the length of hypotenuse C in a right triangle with a given length on each of the other two sides A and B, where $C = \sqrt{A^2 + B^2}$ must be solved for in the form of $f(AB) = \sqrt{(A^2 + B^2)}$



(1) Programming

Mode: AER-I

Program title: PYTHAGORAS

Key in	Display	Remarks
	01:TITLE?	
P Y T H A G O R A S	01:PYTHAGORAS_	Program title name is input.
ENT	M:_	Title name is stored.
f( )=/? A B f( )=/? √	M:f(AB)=√(A²+B²)	Main routine is input
(A x^2 + B x^2)	_	
ENT	02:TITLE?	Main routine is stored.

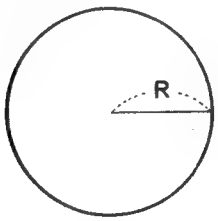
This program consists of a main routine only. Now, let's execute the program by giving values 3 and 4, respectively, to two variables A and B in the expression.
Remember, you need to change the calculator's mode of operation to the COMP mode before executing any expressions you have programmed in the AER-I or AER-II mode.

(2) Program Execution (where A = 3, B = 4)
Mode: COMP

Key in	Display	Remarks
	COMP MODE Ø .	
TITLE PRO	Ø1 : PYTHAGORAS	Program title is searched.
COMP	A = ?	The calculator is asking you for the value of A.
3 COMP	B = ?	The calculator is asking you for the value of B.
4 COMP	ANS 1 =	
	5 .	Length of C is given as Answer 1.

NOTE: The calculator displays the symbol "ANSOO= " (variable name) and then the value of an answer.

Example 2: Area of Circle and Circumference
To solve for the area S of a circle and its circumference L with the value of the radius R of the circle given as a variable using the programming format $f(R)=\pi R^2$, $2\pi R$ for $S=\pi R^2$, $L=2\pi R$



More than one algebraic expression may be written on a program line by separating them with the space " ␣ " or comma " , " key. If two expressions are separated by a space, the calculator will execute the expression immediately after the space without displaying the result of the expression immediately before the space. If they are separated by a comma, the calculator will display the result of the preceding expression before proceeding to the following one.

(1) Programming
Mode: AER-I
Program title: CIRCLE

Key in	Display	Remarks
	Ø2 : T I T L E ?	
C I R C L E	Ø2 : C I R C L E _	
ENT	M : _	
f( )=/? R f( )=/? π R	M : f (R) = πR², 2πR_	
x^2 , 2 π R		
ENT	Ø3 : T I T L E ?	

In the above example, two expressions are separated by a comma. Now, let's execute the program by giving two values 5 and 10 to variable R in the two expressions.

(2) Program execution
Mode: COMP

Key in	Display	Remarks
TITLE PRO	C O M P M O D E Ø2 : C I R C L E Ø.	
COMP	R = ?	
5 COMP	A N S 1 = 7 8 . 5 3 9 8 1 6 3 4	5 is input as value of variable R. Answer to 1st. expression (area S).
COMP	A N S 2 = 3 1 . 4 1 5 9 2 6 5 4	Answer to 2nd expression (circumference L).
COMP	R = ?	
10 COMP	A N S 1 = 3 1 4 . 1 5 9 2 6 5 4	10 is input as value of variable R. Answer to 1st. expression (area S).
COMP	A N S 2 = 6 2 . 8 3 1 8 5 3 Ø 7	Answer to 2nd expression (circumference L).

Example 3: Plotting Program
To solve for f (A) = $3A^2 + 7A + 9$ with the value of A being as 1, 2, 3, ...

(1) Programming
Mode: AER-I
Program title: PLOT

Key in	Display	Remarks
	Ø3 : TITLE?	
P L O T	Ø3 : PLOT_	
ENT	M : _	
A + 1 STO A	M : A+1⇒A, 3A²+7A+9	
, 3 A x^2 +	_	
7 A + 9		
ENT	Ø4 : TITLE?	

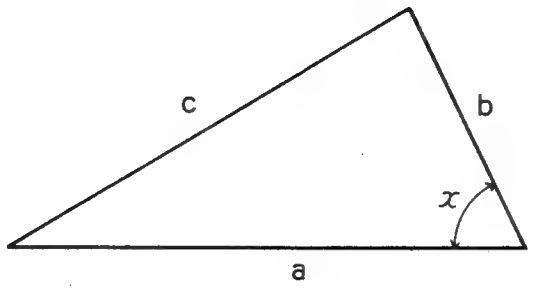
(2) Program Execution
Mode: COMP

Key in	Display	Remarks
	COMP MODE	
TITLE PRO	Ø3 : PLOT	
0 STO A	Ø⇒A	
COMP	ANS 1 = Ø.	
COMP	ANS 2 = 1.	Answer to 1st. expression A=1
COMP	ANS 1 = 19.	Answer to 2nd expression with the value of A given as 1.
COMP	ANS 2 = 2.	Answer to 1st. expression A=2
⋮	⋮ 35.	Answer to 2nd expression with the value of A given as 2.
COMP	ANS 1 =	
COMP	ANS 2 = 5.	
	119.	

NOTE: In the above example, the number displayed at the rightmost position of the line (row) below "ANS" indicates that the answer is that of the 1st. or 2nd expression separated by a comma.

Example 4: Cosine Rule Program

$$c=\sqrt{a^2+b^2-2ab\ COS\ x}$$



(1) Programming
Mode: AER-II
Program title: Cosine

Key in	Display	Remarks
	Ø4 : T I T L E ?	
SHIFT C O S I	Ø4 : C o s i n e _	
N E		
ENT	M : _	
C = √ (A	M : c = √ (a ² + b ² − 2 a × b	
x^2 + B	C O S x) _	
x^2 − 2 A ×		
B COS		
X)		
ENT	Ø5 : T I T L E ?	

Let's execute the above program with the values of variables a, b, and x given as 4, 7, and 60°, respectively.

(2) Program execution (where a = 4, b = 7, x = 60 °)
Mode:COMP

Key in	Display	Remarks
TITLE PRO	COMP MODE Ø 4 : Cosine Ø .	
2ndF DRG		Press until DEG is desig nated.
COMP	a = ?	
4 COMP	b = ?	4 is stored in variable a.
7 COMP	x = ?	7 is stored in variable b.
60 COMP	c =	60 is stored in variable x.
	6 . Ø 8 2 7 6 2 5 3	Answer for length c

Variable Data Check by Playback Function
When executing any of the programs (algebraic expressions) stored in memory, the calculator holds the number (or value) entered as a variable until the next input. To confirm the number already stored in memory, press the **PB** key and the number will be recalled to the display from memory.

Example: Cosine Rule Program

$$c = \sqrt{a^2 + b^2 - 2ab\cos x}$$

In this example, the above program is executed using the playback function with the following values given to the respective variables.
(1) a=4, b=7, x=60
(2) a=4, b=7, x=50

Mode: COMP

Key in	Display	Remarks
TITLE PRO	COMP MODE Ø4 : Cosine Ø.	
2ndF DRG		Press until DEG is designated.
COMP	a = ?	
4 COMP	b = ?	
7 COMP	x = ?	
60 COMP	c =	
	6.Ø8276253	
COMP	a = ?	
PB	a = 4.	The number stored in variable a is displayed.
COMP	b = ?	
PB	b = 7.	The number stored in variable b is displayed.
COMP	x = ?	
50	x = 50_	The number stored in variable x is displayed.
COMP	c =	
	5.385526331	

Program Title Search Functions

• Sequential search

This function allows you to search the title names of the programs (expressions) stored in memory one by one (in ascending order of title numbers) at each depression of the **PRO (TITLE)** key.

In the AER-I mode, pressing the **PRO (TITLE)** key causes only the program titles written in the AER-I mode to be searched in ascending sequence of title numbers.

(Example) 01: PYTHAGORAS, 02: CIRCLE, 03: PLOT

In the AER-II mode, pressing the **PRO (TITLE)** key causes only the program titles written in the AER-II mode to be searched in ascending sequence of title numbers.

(Example) 04: Cosine, 05: Qudratic, 06: Down

In the COMP mode, pressing the **PRO (TITLE)** key causes all the program titles to be searched in ascending sequence of title numbers irrespective of whether they are written in the AER-I or AER-II mode.

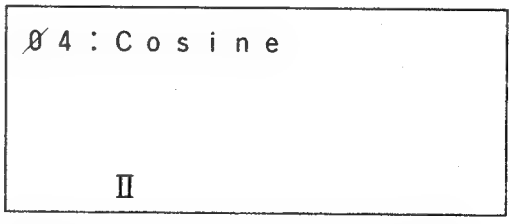
(Example) 01: PHYTAGORAS, 02: CIRCLE, 03: PLOT, 04: Cosine, 05: Qudratic, 06: Down

To execute any of the programs stored, you must perform the program title search operation with the calculator in the COMP mode and then press the **COMP** key when the desired title is recalled on the display.

To correct any of the stored programs, you must perform the program title search operation with the calculator in the AER-I or AER-II mode, and then press the **2ndF** and [▽] keys to display the program contents when the desired title is recalled on the display.

NOTE: 1. The **PRO (TITLE)** key causes program title names to be displayed, commencing with the one last accessed.
2. The **PRO (TITLE)** key may be pressed and held down to search program title names quickly in ascending order.
3. Program title names can be searched in descending order of title numbers by pressing the **2ndF** and **PRO (TITLE)** keys. Holding down the **PRO (TITLE)** after **2ndF** allows quick review of titles in descending order.

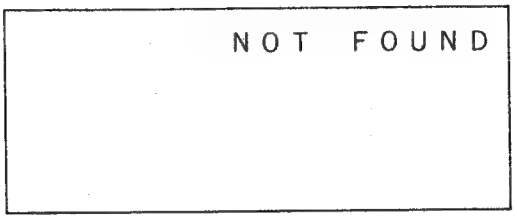
[C] [TITLE PRO] [TITLE PRO]



Program title names with the same initial character are searched in ascending order of title numbers.

If none of the programs commencing with character "Z" exists in memory, the calculator will return the following message to you.

Z TITLE PRO



The initial character search function is effective only for the alphabetic and numeric characters that can be input in the COMP mode.

NOTE: If a program title name has been entered using function keys such as **SIN** and **COS** , such a title name cannot be searched directly even though the key operation: **S PRO** or **C PRO** is performed. A message "NOT FOUND" is also displayed in this case.

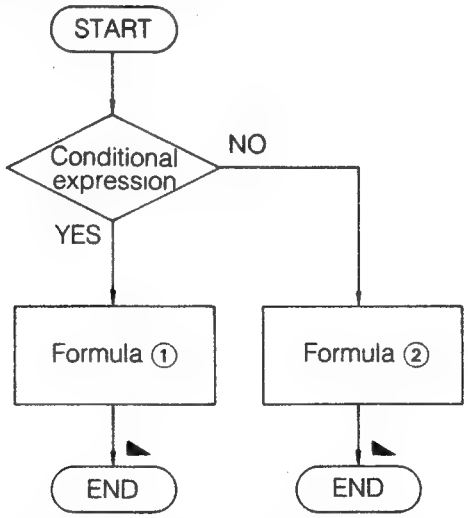
Conditional Expression Judgment Function

The calculator compares the left side of a conditional expression (in which >, >=, or ≠ sign is used) with its right side, and determines the destination of the calculation to be executed next based on the result of the comparison. If the condition in the conditional expression is satisfied, the calculator executes the calculation or operation enclosed with brackets preceded by ■Y➡. If not satisfied, the unit executes the calculation or operation enclosed with brackets preceded by ■N➡.

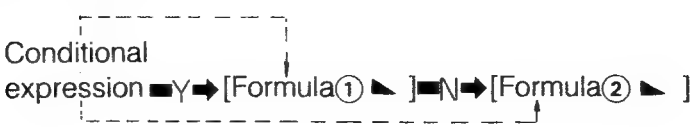
NOTE: A conditional expression cannot be used inside the ■Y➡ **[ ]** or ■N➡ **[ ]** brackets.

You can write a conditional expression in the following forms:
Left side > Right side
Is left side greater than right side?
Left side ≠ Right side
Is left side unequal to right side?
Left side > = Right side
Is left side equal to or greater than right side?

Example 1:
Flowchart of Conditional Judgment Function



In case of the conditional expression as shown in the above flowchart, the basic configuration of the main routine should be as follows:



If a given condition is satisfied (if YES), formula ① is executed.
If a given condition is unsatisfied (if NO), formula ② is executed.
This decision is made using the ■Y➡[ ] and ■N➡[ ] keys.

NOTE: Either of ■Y➡[ ] or ■N➡[ ] may be omitted from entry as shown below.

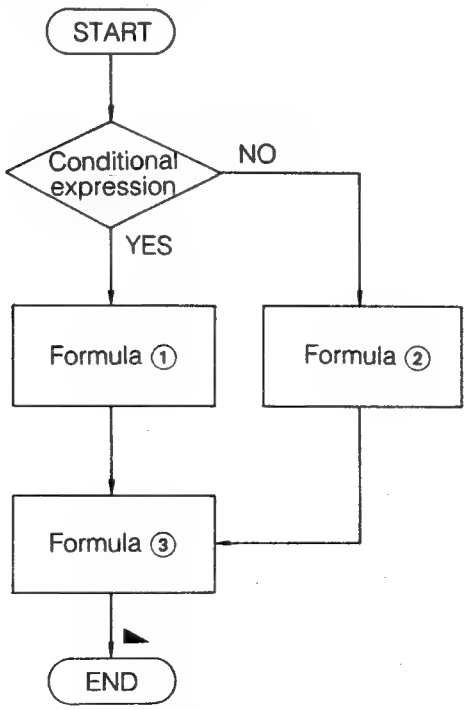
(1) When ■N➡[ ] is omitted

Conditional expression ■Y➡[Formula ①◣] Formula ②◣

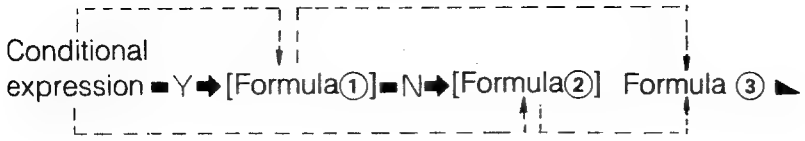
(2) When ■Y➡[ ] is omitted

Conditional expression ■N➡[Formula ②◣] Formula ①◣

Example 2:
Flowchart of Conditional Judgment Function



In case of the conditional expression as shown in the above flowchart, the basic configuration of the main routine should be as follows:



If YES, formula ③ is executed after formula ①. If NO, formula ③ is executed after formula ②.

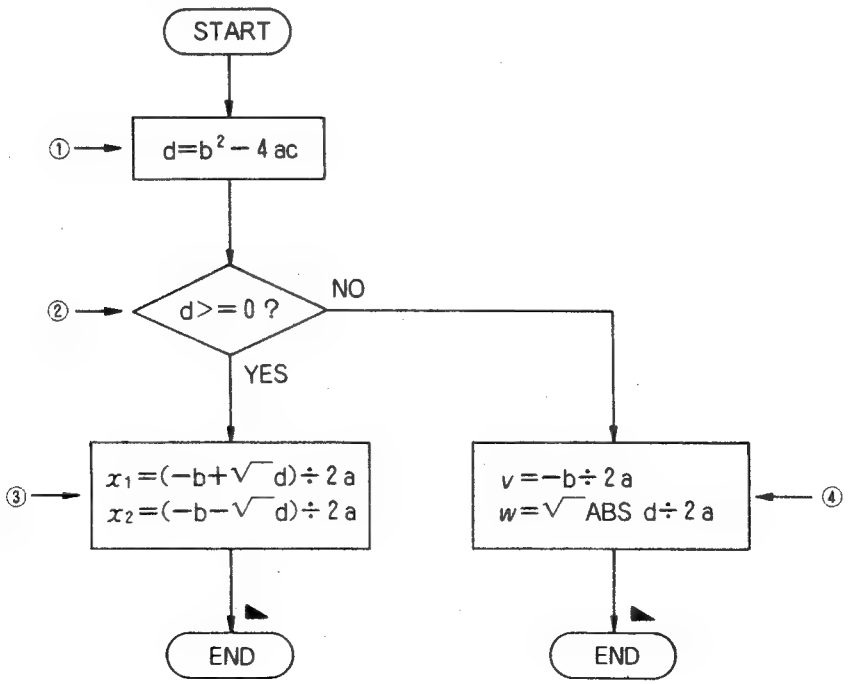
• To terminate a series of calculations, **2ndF** [▶] (Calculation End Command) must be entered after the last formula in the series.

Example 4: Quadratic equation
Let's solve for $ax^2 + bx + c = 0$, where $a \neq 0$ and a, b, and c are real numbers.
The quadratic equation can be solved by the following formula:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

With the value of the discriminant $d = b^2 - 4ac$ under $\sqrt{\ }$, real numbers are solved for if $d \geq 0$, and conjugate imaginary numbers are solved for if $d < 0$.

• Flowchart of expression



Formula ① is a discriminant.
Conditional expression ② determines if the value d of the discriminant is equal to or greater than 0.
Formula ③ solves for real numbers.
Formula ④ solves for imaginary numbers (where v is the real part and w is the imaginary part).

- Program configuration

M : 1 d>=0 ➡Y➡ [2◣] ➡N➡ [3◣]
1 : $d=b^2-4a\times c$
2 : $x_1=(-b+\sqrt{\ }d)\div 2a$, $x_2=(-b-\sqrt{\ }d)\div 2a$
3 : $v=-b\div 2a$, $w=\sqrt{\ }$ABS $d\div 2a$

(1) Programming

Key in	Display	Remarks
	Ø5 : TITLE?	
SHIFT Q U A D	Ø5 : Quadratic_	
R A T I C		
ENT	M : _	
2ndF I D 2ndF >=	M : 1 d >= 0 − Y→ [2◣] − N	
0 2ndF -Y→[] 2ndF 2 2ndF	→ [3◣] _	
◣ 2ndF -Y→[] 2ndF		
-N→[] 2ndF 3 2ndF ◣ 2ndF		
-N→[]		Main routine is stored.
2ndF SUB:	1 : _	
D = B x^2 −	1 : d = b ² − 4 a × c _	
4 A × C		Subroutine 1 is stored.
2ndF SUB:	2 : _	
X SHIFT I = ((−)	2 : x_1 = (− b + √ d) ÷ 2 a,	
B + √ D)	x_2 = (− b − √ d) ÷ 2 a _	

(To be continued on next page)

Key in	Display	Remarks
÷ 2 A , X SHIFT 2 = ((−) B − √ D) ÷ 2 A		
2ndF SUB:	3 : _	Subroutine 2 is stored.
V = (−) B ÷ 2 A , W =	3 : v = − b ÷ 2 a , w = √ A B S	
√ 2ndF ABS D ÷ 2 A	d ÷ 2 a _	
ENT	Ø 6 : T I T L E ?	Subroutine 3 is stored and the program is completed.

Let's execute the above program with values 2, −4, and 1, given to variables a, b, and c, respectively, in subroutine 1 .

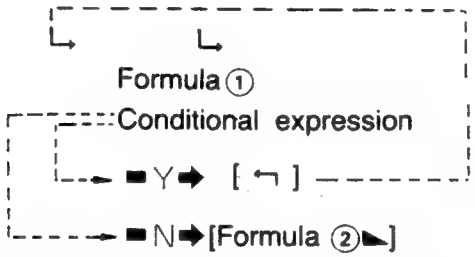
(2) Program execution (where a=2, b=−4, c=1)
Mode: COMP

Key in	Display	Remarks
	C O M P M O D E	
TITLE PRO	Ø 5 : Q u a d r a t i c Ø .	
COMP	b = ?	Value −4 is stored in variable b. Value 2 is stored in variable a. Value 1 is stored in variable c.
(−) 4 COMP	a = ?	
2 COMP	c = ?	
1 COMP	x_1 =	
	1 . 7 Ø 7 1 Ø 6 7 8 1	
COMP	x_2 =	
	Ø . 2 9 2 8 9 3 2 1 9	

In this example, the two expressions in subroutine 2 have been executed because the value d of the discriminant was greater than or equal to 0 as the result of the conditional expression judgment in the main routine execution.

Looping Function

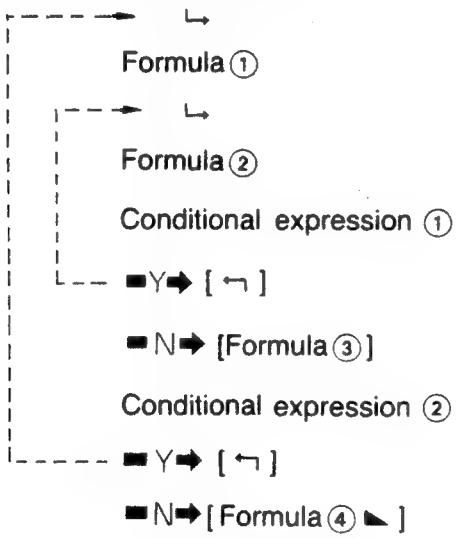
The looping function permits the same calculation or processing to be repeated over and over again. This function is designated in a series of calculation procedures by using two commands: " ↳ " (Return here) and " ↰ " (Return from here to " ↳ " command).
The basic looping format is as shown below.



If YES, execution returns to formula ①, and if NO, formula ② is executed.

NOTE: Up to 15 loops can be nested.

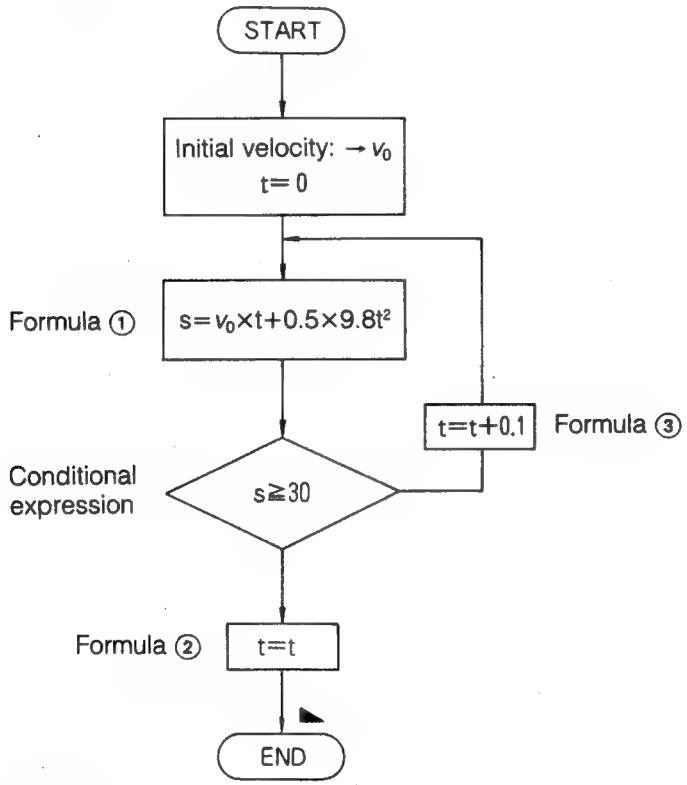
Example:
Double-looped conditional expressions



NOTE: >,>=, ≠, Y [ ], N [ ], ↳, and ↰ cannot be used in a subroutine.

Let's write a program expression using both the conditional judgment and looping functions.
Example : Program "Down"
To solve for the approximate value of the time when a ball falling from the point 30 meters above the ground at the initial velocity of v_0 (m/s) reaches the ground
Falling distance $s = v_0 \times t + 0.5 \times 9.8t^2$

- Flowchart of expression



- Program configuration

↳ Formula ① conditional ■ Y ➡ [Formula ② ◣]
expession
■N➡ [Formula ③ ↰]

Remember, you must use the AER-II mode to write this program, as it uses lowercase letters as variables.

(1) Programming
Mode: AER-II
Program title: Down

Key in	Display	Remarks
	06 : TITLE?	
SHIFT D O W N	06 : Down_	
ENT	M : _	
2ndF ↳ S = V	M : ↳s=vo×t+0.5×9.	
SHIFT 0 × T +	8t²⌴s>=30-Y→[t=t	
0.5 × 9.8 T x^2	◣]-N→[t=t+0.1↰]_	
⌴ S 2ndF		
>= 30 2ndF -Y→[] T		
= T		
2ndF ◣ 2ndF -Y→[] 2ndF		
-N→[] T = T +		
0.1 2ndF ↰ 2ndF -N→[]		
ENT	07 : TITLE?	

Let's execute the above program with values 3 and 0 given to variables v_0 and t, respectively.

(2) Program execution (where v_0=3, t=0)
Mode: COMP

Key in	Display	Remarks
	COMP MODE	
TITLE PRO	0.	
	06 : Down	
COMP	vo = ?	
3 COMP	t = ?	
0 COMP	t =	
	2.2	The approximate value of the time is 2.2 seconds.

Programming of Graphics Commands

With this calculator, you may incorporate six graphics commands into a program you write in the AER-I or AER-II mode and then execute it in the COMP mode.

Commands that can be programmed

GRAPH , AUTO , DRAW , PLOT , ZOOM , RANGE , 2ndF LINE

Input procedure

(1) If the range parameters are to be set within a program, they must be entered in the following order:

RANGE Xmin [,] Xmax [,] Xscl [,] Ymin [,]
Ymax [,] Yscl [␣]

(2) Other graphics commands may be written into a program in basically the same manner as those entered in the COMP mode.

Example:
Programming the drawing of a graph for expression $y = x^3 + 2x^2$ with the range parameters set as follows:
Xmin = −3, Xmax = 3, Xscl = 1
Ymin = −5, Ymax = 10, Yscl = 2

Mode: AER-I

[G] [R] [A] [P] [H] 1
[ENT]

```
M : _


  I
```

[RANGE] [(−)] 3 [,] 3 [,] 1 [,]
[(−)] 5 [,] 10 [,] 2 [␣]

```
M : R A N G E  − 3 , 3 , 1 , −
5 , 1 Ø , 2 ␣ _


  I
```

GRAPH X Y^x 3 + 2 X x^2 DRAW

```
M:RANGE -3,3,1,-
5,10,2␣GRAPH XY^x
3+2X² DRAW_

I
```

ENT

```
Ø8:TITLE ?

I
```

NOTE: When you input an expression for a graph in the AER-II mode, use uppercase letter **X** (**SHFT X**).

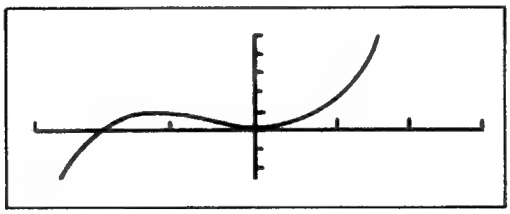
Mode: COMP

TITLE PRO

```
Ø7:GRAPH1

←I                →
```

COMP



Correcting Program Title Name Entry

During the input of a program in the AER-I or AER-II mode, if you find an error in the title name of the program, press the [◁] or [▷] key to move the cursor to the point where an incorrectly entered character exists. Enter the correct character at the point where the cursor blinks.

- The **DEL** key causes the character at the cursor position to be deleted.
- The **2ndF** and **INS** keys cause all the characters at the right of the cursor position to move to the right by one digit. Then the " ⌴ " indicator appears at the cursor position to prompt you to insert the correct character at that position.

Example:

To correct the program title name erroneously entered during programming to read from "Cosain" to "Cosine"

Mode: AER-II

Key in	Display	Remarks
	Ø8 : TITLE?	
SHIFT C O S A I N	Ø8 : Cosain_	
◁ ◁ ◁ I N		
E	Ø8 : Cosine_	Title name is corrected.
ENT	M : _	
C = √ (A	M : c=√ (a² + b² − 2 a × b	
x^2 + B x^2 −	COS x) _	
2 A × B COS		
x)		
ENT	Ø9 : TITLE?	

In either case, be sure to press the **ENT** key at the end of the correction.

Correcting Program Contents

• To correct the contents of a program (one or more algebraic expressions) stored in memory, perform the program title search operation in the AER-I or AER-II mode to recall the title of the program you wish to correct on the display. Then press the [▽] key and the contents of the main routine will be displayed. If the program has any subroutines, press the **2ndF** and [▽] keys consecutively to display the subroutines. As you did in the title name correction, move the cursor to the point on a program line where you wish to make corrections and then enter character(s) for correction.

• Press the **ENT** key after you have completed the correction of each main routine line or subroutine line.

NOTE: The data for a flexible variable will be cleared upon correction of the expression (or program) in which the flexible variable is used.

Deleting or Clearing Program Contents

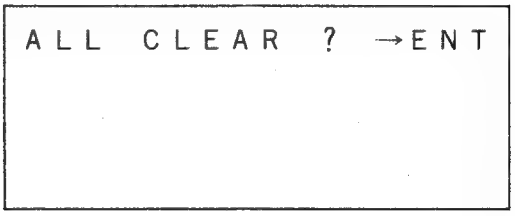
• To delete a specific program line (an algebraic expression) from a program, call the program title of the program you wish to delete on the display using the **PRO (TITLE)** key, locate the line to be deleted using the **2ndF** and [▽] keys in the AER-I or AER-II mode, and then press the **2ndF** and **CA** keys. The line has now been deleted from memory.

• To delete a specific program from memory, call the program title of the program you wish to delete on the display by the program title search operation in the AER-I or AER-II mode, and press the **2ndF** and **CA** keys. The following message will appear on the display.

```
OO:CLEAR ? →ENT
```

Then press the **ENT** key and the program (program title name, main routine, and subroutines) will be deleted from memory. Memory contents will be retained by pressing the **CL** key.

• To clear all the programs stored in memory, push the Reset switch at the rear of the calculator in the AER-I or AER-II mode, and the following message will appear on the display.



Then press the **ENT** key and all the programs stored in the AER-I or AER-II mode will be cleared from memory.
(In this case, all the memories including store memories and array variable memories are cleared.)

When the Reset switch is operated, the calculator's key click mode may be reset or its display may become dim. If so, set the key click mode again or readjust the contrast of the display.

Memory contents will not be cleared when any key other than **ENT** is pressed.

CHAPTER 6
OPTIONS

SHARP options such as the CE-50P printer/cassette interface, and CE-152 cassette tape recorder can be connected to the calculator.

When these options are connected to the calculator, you may save the contents of the calculator's memory or display onto cassette tape or have them output on the printer as hard copy. Or you may even have your calculator communicate with another EL-9000 unit via the CE-200L interface cable. For connecting the calculator to any of these options, refer to the operation manuals supplied with the respective options.

Printer-Related Functions

When the optional CE-50P printer/cassette interface is connected to the calculator, the following printer-related functions are available.
(1) Hard-copy output of screen image or data
(2) Program listing
(3) Printing all data of a data group (i.e., all data in a matrix)

Option Selection Menu
When the CE-50P printer/cassette interface is connected to the calculator, pressing the **2ndF** and **OPTION** keys causes the following option selection menu to be displayed.

Option selection menu screen

2ndF OPTION

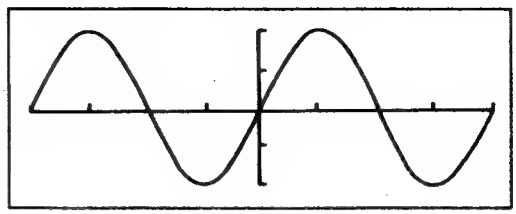
```
COPY  DISP  →1 2 3 4
PRINT       →5
SAVE        →6
LOAD        →7
```

The above option selection menu screen indicates the following:
COPY DISP ... One of the numeric **1** through **4** keys must be pressed to specify the print character size as follows.
1 : Prints characters in standard size
2 : Prints characters in twice as large as the standard size.
3 : Prints characters in three times as large as the standard size.
4 : Prints characters in four times as large as the standard size.
PRINT ..... Numeric **5** key must be pressed to specify the PRINT operation.
SAVE ..... Numeric **6** key must be pressed to display the save-related option selection menu.
LOAD ..... Numeric **7** key must be pressed to specify the LOAD operation.

The menu screen can be canceled by pressing the **2ndF** and **OPTION** keys again. This key operation causes the display to return to the original screen (i.e., before selecting the option selection menu screen).

Hard-copy Output of Screen Image or Data
The contents of the display screen are output on the printer connected to the calculator upon pressing any of the numeric **1** through **4** keys following the display of the option selection menu by the **2ndF OPTION** key operation.

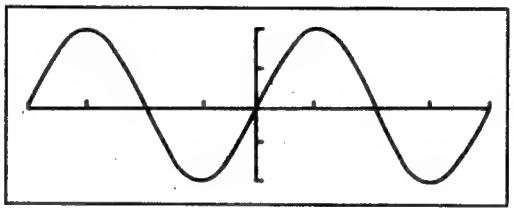
GRAPH SIN DRAW



2ndF OPTION

```
COPY DISP →1 2 3 4
PRINT     →5
SAVE      →6
LOAD      →7
```

1



Upon pressing the numeric **1** key, message "PRINTING" appears on the display together with the flashing "←" and "→" symbols, and the contents of the screen are output on the printer.
During the above operation, pressing the **BREAK (ON)** key causes a break (interruption) in the COPY DISPLAY operation.

Program Listing

The title name of a program to be printed must be first displayed using the **PRO (TITLE)** in the AER-I or AER-II mode. Then press the **2ndF** and **OPTION** keys to display the option selection menu and press the numeric **5** key to specify the Print operation.

TITLE PRO ..... TITLE PRO

```
Ø5 : Quadratic


     II
```

2ndF OPTION

```
COPY  DISP  →1 2 3 4
PRINT       →5
SAVE        →6
LOAD        →7
```

5

(PRINTOUT)

```
05:Quadratic

M:Ad>=0⇒Y◆[B◣]⇒N
◆[B◣]

A:d=b²-4a×c

B:x₁=(-b+√d)÷2a,
x₂=(-b-√d)÷2a

B:v=-b÷2a,w=√ABS
 d÷2a
```

```
PRINTING
←                →
```

Upon pressing the numeric **5** key, message "PRINTING" appears on the display together with the flashing "←" and "→" symbols, and the calculator starts listing the contents of the displayed program (including the program title name). Upon completion of the printing, message "TITLE?" appears on the display. During the above operation, pressing the **BREAK (ON)** key causes a break (interruption) in printing.

Printing All Data of a Data Group (all data in a matrix)

The data title name of a statistical data group (or a matrix) to be printed must be first displayed by using the **DATA (TITLE)** key and ▽ or △ key in the STAT or COMP mode. Then press the **2ndF** and **OPTION** keys to display the option selection menu and press the numeric **5** key to specify the Print operation.

Mode: COMP

TITLE
DATA

```
S : [ 2 , 3 ] , P
  : T E S T 1
T : [ 0 , 0 ]
  :
  ↑              ↓
```

2ndF OPTION

```
COPY  DISP  →1 2 3 4
PRINT       →5
SAVE        →6
LOAD        →7
```

5

(PRINTOUT)

```
S:[2,3],P
 :TEST1
S[1,1]=
                15.
S[2,1]=
                20.
S[1,2]=
                 8.
S[2,2]=
                12.
S[1,3]=
                35.
S[2,3]=
                17.
```

```
PRINTING
```

The calculator starts listing the specified data group (including the data title name) upon pressing the numeric **5** key and then the display returns to the original screen.
During the above operation, pressing the **BREAK (ON)** key causes a break (interruption) in printing.

NOTE: When printing all data of a data group (or all data in a matrix), 48 lines of data are transferred at a time to the printer.

Cassette-Related Functions

When the optional CE-152 cassette tape recorder is connected to the calculator via the CE-50P printer/cassette interface, the following cassette-related functions are available.

(1) Saving a program to cassette
(2) Saving all data of a data group to cassette
(3) Saving the contents of all memories (data and programs) to cassette
(4) Loading the contents of the cassette tape to calculator

Saving a Program to Cassette

With the REMOTE switch of the CE-50P printer/cassette set in the ON position, the RECORD button of the cassette tape recorder must be pushed to put the recorder in the ready state for recording. Then the title (or list) of the program to be recorded on cassette tape must be displayed using the **PRO (TITLE)** key in the AER-I or AER-II mode.

Press the **2ndF OPTION** keys to display the option selection menu screen and then the numeric **6** key to display the SAVE-related option menu screen.

When you press the numeric **1** key, the "SAVE" operation is specified. Press the **ENT** key following the file name entry (e.g., **SHIFT QU** for "Quadratic") and the calculator will start saving the program onto cassette tape.

Mode: AER-II

TITLE PRO ··· TITLE PRO

```
05 : Quadratic


   II
```

2ndF OPTION

```
COPY  DISP  →1 2 3 4
PRINT       →5
SAVE        →6
LOAD        →7
```

[6]

```
SAVE FILE

SAVE          →1
SAVE ALL      →2
```

[1]

```
SAVE FILE NAME:
?
```

[SHIFT] [Q] [U] [ENT]

```
SAVING
```

Message "SAVING" and flashing "←" and "→" symbols are on the display during the program saving operation. Upon completion of the saving, message "TITLE?" appears on the display.

Saving All Data of a Data Group to Cassette

The data screen or data title of a data group (or array variable) to be saved onto cassette tape must be first displayed using the **DATA (TITLE)** key in the STAT or COMP mode. With the flashing cursor at the position of the array name, press the **2ndF** and **OPTION** keys to display the option selection menu screen and press the numeric **6** key to display the SAVE-related option selection menu.

Press the numeric **1** key to specify the SAVE operation. Upon pressing the **ENT** key following the file name entry, the calculator starts saving the data group in its memories onto cassette tape.

Message "SAVING" and flashing "←" and "→" symbols are on the display during the saving operation and disappear upon completion of the saving, at which time the display returns to the original screen.

Saving the Contents of All Memories (Data and Programs) to Cassette
Irrespective of the calculator's operation mode, press the numeric **6** key to display the save-related option selection menu, following the display of the option selection menu screen with the **2ndF OPTION** key operation. Then press the numeric **2** key to specify the Save All operation. Upon pressing the **ENT** key following the file name entry, the calculator starts saving the contents of all its memories onto cassette tape.

Loading the Contents of the Cassette Tape to Calculator
First set the Mode Selector (slide) switch of the calculator in the same position as when a file to be loaded was saved onto cassette. Then, press the numeric **7** key to specify the Load operation, following the display of the option selection menu screen with the **2ndF OPTION** key operation. Upon pressing the **ENT** key following the file name entry of the file to be loaded, the calculator starts loading the contents of the specified file into its memory.

2ndF OPTION

```
COPY DISP →1 2 3 4
PRINT     →5
SAVE      →6
LOAD      →7
```

7

```
LOAD FILE NAME:
?
```

SHIFT Q U ENT

```
        LOADING
←                →
```

Message "LOADING" and flashing "←" and "→" symbols are on the display during the loading operation and disappear upon completion of the loading, at which time the display returns to the original screen.

NOTE: 1. When transferring data between the calculator and the cassette tape recorder, the data to and from the calculator are stored once in the CE-50P printer/cassette interface for subsequent transfer. The data are being transferred through the CE-50P while message "SAVING" or "LOADING" is on display even if the cassette tape recorder stops during the saving or loading operation. For this reason, do not proceed to the next operation until the message "SAVING" or "LOADING" disappears.

2. An error will result if you attempt to transfer the data of the same array name already defined in the calculator, from the cassette tape recorder to the calculator. Transfer the data after the array variable memory in the calculator has been cleared.
3. If an error occurs during the transfer of the file containing all the memory contents of the calculator from the cassette tape recorder, the contents of all the memories in the calculator will be cleared.

Interface Cable-Related Functions

When the optional CE-200L interface cable is connected between this calculator and another EL-9000 unit, the following functions are available.

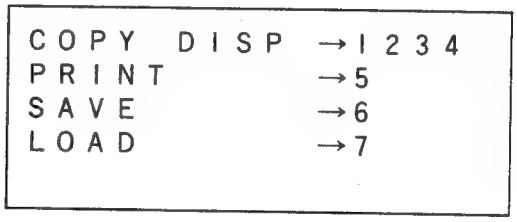
(1) Sending a program to another unit
(2) Sending all programs stored in memory to another unit
(3) Sending the contents of all memories (data and programs) to another unit
(4) Receiving data and programs from another unit

Saving and Loading Operations

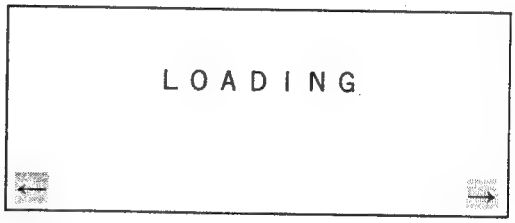
When sending (saving) and receiving (loading) data between two EL-9000 units, observe the following procedure.

[Receiving unit]

2ndF OPTION



7



(1) First put the receiving unit in the ready state for receiving data by pressing the numeric **7** key to specify the LOAD operation following the display of the option selection menu by the **2ndF OPTION** key operation.

[Sending Unit]

(2) Call the program or data group to be sent on the display of the sending unit. Use the **PRO (TITLE)** key in the AER-I or AER-II to display the title (or list) of the program. Use the **DATA (TITLE)** key in the COMP or STAT mode to display the array name of the data group together with the flashing cursor.

(3) Operate the **2ndF** and **OPTION** keys of the sending unit to display the

option selection menu and then press the numeric **6** key to specify the SAVE operation. (With this key operation, the sending unit is put in the ready state for sending data to the receiving unit.)

TITLE
PRO

```
Ø5 : Quadratic


   II
```

2ndF OPTION

```
COPY  DISP  →1 2 3 4
PRINT       →5
SAVE        →6
LOAD        →7
```

6

```
SAVE FILE

SAVE        →1
SAVE ALL    →2
```

Pressing the numeric **1** key causes only the displayed data to be sent, whereas pressing the numeric **2** key causes all data stored in memory to be sent.
Press the numeric **1** key of the sending unit and message "SAVING" and flashing " ←" and "→" symbols appear on the display, indicating the start of the saving operation and disappear upon completion of the saving, at which time the display returns to the original screen.

1

```
        SAVING


←                    →
```

(4) Message "LOADING" and flashing "←" and "→" symbols appear on the display of the receiving unit, indicating the start of loading operation, and disappear upon completion of the loading operation, at which time the display returns to original screen.

APPENDIXES

Appendix A
Operating Controls

Unless otherwise specified, the keys listed below can be used in any of the COMP, STAT, AER-I, and AER-II mode.

•Left-hand Keyboard

Mode Selector (Slide Switch)

AER-I: Algebraic Expression Reserve Mode
This mode is used to program algebraic expressions in the form of f( )= which use store memories A through Z and array variable memories A[ ] through Z[ ] into the calculator's memory. In this mode, no calculation can be performed.

AER-II: Algebraic Expression Reserve Mode
This mode is used to program algebraic expressions in the form of a=b+c which use flexible variables in addition to store memories and array variable memories. Also in this mode, no calculation can be made.

COMP: Computation mode
This mode permits the calculator to perform all calculations including four basic arithmetic operations, scientific calculations, matrix operations, and calculations that use algebraic expressions programmed in the AER-I or AER-II mode but excluding statistical calculations. The calculator can also graph expressions and formula as well as to perform other graphic functions.

STAT: Statistical calculation mode
This mode permits the calculator to perform single-variable and two-variable statistical calculations and to draw statistical graphs such as histogram, broken-line graph, cumulative frequency graph, normal distribution graph, scatter diagram, linear regression, etc. In this mode, the calculator can be set in either of the DATA STORE and NON-STORE submodes.

BREAK
ON

: Power ON/Break key
Used to turn on the power of the calculator.

COMP or STAT mode:
Pressing this key during the execution of a program (algebraic expression) or a graphic drawing breaks the

execution. Also used to interrupt the output of data onto the option printer or cassette tape, as well as the saving and loading operations between the calculator and cassette tape recorder.

[OFF] : Power OFF key
Used to turn off the power of the calculator.

[2ndF] : 2nd Function Key
Two **2ndF** keys are provided, one on each keyboard. Either of the two may be used to designate the second function of another key. The second function is printed in yellow above the key itself on the left-hand keyboard or above the touch key on the right-hand keyboard.
NOTE: If either of the two keys is pressed by mistake, press the key again to cancel the second function designation.

[CL] : Clear Key
Also used to release the calculator from an error condition.
COMP mode:
Used to clear numeric data or calculation commands from the display. The memory contents or programs will remain unchanged even after the clear operation.
Also used to release the calculator from an error condition.
AER-I or AER-II mode:
Used to move the cursor to the beginning of the current line. If this key is pressed while a program title (with no cursor) is in the display, the title will be replaced with a message "O O:TITLE?".
Also used to release the calculator from an error condition.

[2ndF] [CA] : Clear All Key
COMP or STAT mode:
Used to clear numeric data or calculation commands. The memory contents or programs will remain unchanged even after the clear operation. Also used to clear the result of a statistical calculation or statistical data entered in the STAT mode. However, in the DATA STORE mode, these keys must be preceded by the [DATA] key to clear statistical data. The contents of store memories A to Z will remain unchanged.
AER-I or AER-II mode:
If these keys are pressed while program contents are in

the display, the program line now in the display will be cleared. If they are pressed while a program title is in the display, the title will be replaced with a message "○ ○: CLEAR? → ENT". Pressing the **ENT** key will delete the program of that title.

[△] , [▽] : Cursor Up and Down Keys
Used to move the cursor up or down, respectively, by one row (or line). While this key is being pressed and held, the cursor moves up or down, respectively, in quick succession.

[◁] , [▷] : Cursor Left and Right Keys
Used to move the cursor left or right, respectively, by one digit (or column). While this key is being pressed and held, the cursor moves left or right, respectively, in quick succession.

[SHIFT] [▽]
[SHIFT] [△] : Contrast Adjustment Keys
Used to adjust the display for lower or higher contrast, respectively. (See **SHIFT** key on the right-hand keyboard.)

[2 ndF] [▽] AER-I or AER-II mode:
: Used to scroll a stored program one line after another in the forward direction (from main routine to subroutine).
While these keys are being pressed and held, program lines are scrolled in quick succession.

[2 ndF] [△] AER-I or AER-II mode:
: Used to scroll a stored program one line after another in the backward direction (from subroutine to main routine).
While these keys are being pressed and held, program lines are scrolled in quick succession.

[2ndF] [T▶G▶D] : Text/Graphics/Data Screen Selection Key
Used to select the text screen, graphics screen, and data screen by rotation.

[2ndF] [X↔Y] : X↔Y Coordinate Value Selection key.
Used to display the values of x and y coordinates alternately.

[2ndF] [G.CL] : Graphics Screen Clear Key
COMP or STAT mode:
Used to clear all the contents of the graphics screen except the x- and y-axes.

[2ndF] [M.CK] : Memory Check Key
The remaining capacity of the memory is indicated in bytes on the display while these keys are being pressed and held. (See APPENDIX C.)

[FSE] : Display Mode Designation Key
COMP mode:
Used to select the display mode from FIX, SCI, and ENG.

[2ndF] [DRG] : Degrees/Radians/Grads Selection Key
Used to designate the unit of angle (DEG, RAD, or GRAD) for calculation of trigonometric and inverse trigonometric functions and for conversion of coordinates. Each depression of these keys causes the unit of angle to be changed from one unit to another.

[TAB] : Tabulation Key
COMP mode:
Used to fix the number of decimal positions in a calculation result. The number of digits (0 through 9) must be entered following this key.

[2ndF] [MDF] : Modify Key
COMP mode:
Used to match the internal calculation result stored in memory with the calculation result in the display.

[PB] : Playback Key
COMP or STAT mode:
Pressing this key allows you to check or correct all of the inputs or to display the last executed expression for re-execution.

AER-I or AER-II mode:
Used to display the contents of 4 program lines.

[2ndF] [RND] : Random Number Generation Key
COMP mode
Used to generate pseudo-random numbers in three significant digits ranging from 0.000 to 0.999.

[DEL] : Delete Key
Used to delete the character (number or letter) at the cursor position. (The cursor does not move.)

[2ndF] [INS] : Insert key
Pressing these keys provides a blank space necessary for insertion of a character (number or letter) into the cursor position by shifting the contents of the display to the right. In the blank space, the insert mark " □ " appears.

[HYP] : Hyperbolic Function Key
Used with the respective trigonometric function keys to calculate hyperbolic functions (SINH, COSH, TANH).

[2ndF] [ARCHYP] : Inverse Hyperbolic Function Key
Used with the respective trigonometric function keys to calculate inverse hyperbolic functions ($SINH^{-1}$, $COSH^{-1}$, $TANH^{-1}$).

[SIN] 、[COS] 、[TAN] : Trigonometric Function Keys
Used to calculate the respective trigonometric functions.

[2ndF] [SIN^{-1}] 、
[2ndF] [COS^{-1}] 、
[2ndF] [TAN^{-1}] : Inverse Trigonometric Function Keys
Used to calculate the respective inverse trigonometric functions.

[→DEG] : D.MS → Decimal Degrees Conversion Key
Used to convert an angle in the sexagenary notation system (degrees, minutes, seconds) into decimal equivalent (in degrees).

[2ndF] [→D.MS] : Decimal Degrees → D.MS Conversion Key
Used to convert an angle in the decimal notation system (in degrees) into sexagenary equivalent (in degrees, minutes, seconds).

[→POL] : Rectangular → Polar Coordinates Conversion Key
Used to convert rectangular coordinates into polar coordinates.

[2ndF] [→REC] : Polar → Rectangular Coordinates Conversion Key
Used to convert polar coordinates into rectangular coordinates.

[NOT] 、[AND] 、[OR] 、[XOR] 、[XNOR] Logical Operator Keys
BIN, OCT, or HEX submode:
: Used to enter logical operators "NOT", "AND", "OR", "XOR" (exclusive OR), and "XNOR" (exclusive NOR), respectively.

[Y^x] : Power Key
Used to raise a number to a power.

[2ndF] [$\sqrt[x]{\ }$] : Power Root Key
Used to obtain the power root of a number.

[LOG] : Common Logarithm Key
Used to obtain the logarithm with base 10.

[2ndF] [10^x] : Common Antilogarithm Key
Used to calculate the antilogarithm with base 10.

[LN] : Natural Logarithm Key
Used to obtain the logarithm with base e (e ≒ 2.718281828).

[2ndF] [e^x] : Natural Antilogarithm Key
Used to calculate the antilogarithm with base e of the displayed number.

[x^2] : Square Key
Used for squaring.

[2ndF] [x^{-1}] : Reciprocal / Inverse Matrix
Used for reciprocal calculations.
MATRIX submode:
Used to define an inverse matrix. (Example: MAT A^{-1})

[$\sqrt{\ }$] : Square Root Key
Used for square root calculations.

[2ndF] [$\sqrt[3]{\ }$] : Cubic Root Key
Used for cubic root calculations.

[π] : Pi Key
Used to enter constant π($\pi \fallingdotseq 3.141592654$).

[2ndF] [n!] : Factorial Key
Used to calculate the factorial n! = n (n-1) (n-2) ... 2 1.

A ~ F
[ ] ~ [ ] Hexadecimal Number Keys
HEX submode:
: Used to enter hexadecimal numbers **A**, **B**, **C**, **D**, **E**, and **F**, respectively.

[RM] : Recall Memory Key
Used to access and display the contents of the independently accessible memory.

[⇒M] : Memory In Key
Used to store a calculation result in the independently accessible memory. When this key is pressed, the previous contents of the independently accessible memory is cleared and replaced with the calculation result. To clear the independent accessible memory, depress the **CL** key followed by the ⇒**M** key. (In this case, 0 (zero) is stored in the memory.)

[M+] : Memory Plus Key:
Used to add a calculation result to the contents of the independently accessible memory.

[2ndF] [M+] : Memory Minus Key
Used to subtract a calculation result from the contents of the independently accessible memory.

[TITLE DATA] Data Title Search Key
COMP or STAT mode
: Used to search the titles of data stored in array variable memories in ascending order of alphabet. While this key is being pressed and held, data titles are searched in quick succession. (In the STAT mode, only array variable memory S (i.e., statistical data input area) is accessed.)

[2ndF] [TITLE DATA] :Used to search data titles in descending order of alphabet. While this key is being pressed and held, data titles are searched in quick succession.

Program Title Search Key
COMP, AER-I, or AER-II mode

TITLE / PRO : Used to search program titles in ascending order of title numbers. While this key is being pressed and held, program titles are searched in quick succession.

2ndF TITLE / PRO : Used to search program titles in descending order of title numbers. While this key is being pressed and held, program titles are searched in quick succession.

COMP : Compute Key
COMP mode
Used to execute a program (algebraic expression) stored in memory in AER-I or AER-II mode.

ENT : Enter Key
AER-I or AER-II mode:
Used to store a program (algebraic expression) in memory.

× , ÷ , + , − : Four Basic Arithmetic Keys
Used for multiplication, division, addition, and subtraction, respectively.

Exp : Exponent Key
Used to enter the exponent part of a number.
Example: 1.234×10^{15}
Key in: 1.234 **Exp** 15

NOTE: The number of digits for the exponent part is 2 digits. A number with a decimal fraction may be entered, but the calculator ignores the decimal point in the calculation process. If more digits are entered, only the last two digits are effective as the exponent.
Example: COMP mode
Key in: 2 **Exp** 1234 = → "2.E34" is displayed.

2ndF ANS : Recall Answer Memory Key
Used to recall the data stored in the answer memory.

0 ~ 9 : Numeric Keys
Used to enter numeric data.
Example: 1234 → 1 2 3 4

[2ndF] [0] ~ [2ndF] [9]

AER-I or AER-II mode:
: Used to enter subroutine numbers **1** through **9** and **0** .

[SHIFT] [0] ~ [SHIFT] [9]

AER-II mode:
Used to enter numbers 0 to 9 reduced in size as variables.
(See **SHIFT** key on the right-hand keyboard.)

[•]

: Decimal Point Key
Used to place the decimal point in the number entered.
Example: 12.3 → **12** [•] **3**

[(−)] [NEG]

: Change Sign Key
Used to enter a negative number.
Example: −2.4 → [(−)] **2** [•] **4**

BIN, OCT, or HEX submode:
Used to obtain the complement of a binary, octal, or hexadecimal number
Example: [2ndF] [→HEX] [NEG] [2] → "NEG 2"
[=] → "F F F F F F F FE"

[(] , [)]

: Open and Close Parenthesis Keys
Used to enter open and close parentheses, respectively.

[=] [SET]

: Equals / Set key
Used to obtain the result of a calculation.

COMP (MATRIX) or STAT mode:
Used to enter matrix elements (data) in a matrix operation, to enter statistical data area S in DATA STORE mode, or to set range parameters.

[2ndF] [→HEX]

: Hexadecimal Number Mode key
COMP mode:
Used to set the hexadecimal number system mode.
Also used to convert the number displayed into a hexadecimal number.

[2ndF] [→BIN]

: Binary Number Mode Key
COMP mode:
Used to set the binary number system mode. Also used to convert the number displayed into a binary number.

[2ndF] [→DEC] : Decimal Number Mode Key
COMP mode:
Used to set the decimal number system mode (normal mode). Also used to convert the number displayed into a decimal number.

[2ndF] [→OCT] : Octal Number Mode Key
COMP mode:
Used to set the octal number system mode. Also used to convert the number displayed into an octal number.

[2ndF] [MATRIX] : Matrix Operation Mode Key
COMP mode:
Used to set the matrix operation mode. When these keys are pressed a second time, the calculator is released from the matrix operation mode.

[2ndF] [nCr] : Combinations Key
Used to determine the number of possible combinations when selecting a specific number of items (r) from any number of different items (n).

[2ndF] [nPr] : Permutations Key
Used to determine the number of possible permutations when arranging a specific number of items (r) selected from any number of different items (n).

[CD] : Data Correction Key
STAT mode:
Used to correct an error in statistical data entry.

[(x,y)] : Two-Variable Data Designation Key
STAT mode:
Used to distinguish between data x and data y in two-variable statistical calculations.

[DATA] : Data Entry Key
STAT mode:
Used to enter data in single- or two-variable statistical calculations.

Statistical Calculation Keys
STAT Mode:

[2ndF] [n] : Used to obtain the number of samples (data) entered in single- or two-variable statistical calculations.

[2ndF] [Σx] : Used to obtain the sum of data x entered in single- or two-variable statistical calculations.

[2ndF] [Σx^2] : Used to obtain the sum of the squares of each data x entered in single- or two-variable statistical calculations.

[2ndF] [Σxy] : Used to obtain the sum of the products of data x and y in two-variable statistical calculations.

[2ndF] [Σy] : Used to obtain the sum of data y entered in two-variable statistical calculations.

[2ndF] [Σy^2] : Used to obtain the sum of the squares of each data y entered in two-variable statistical calculations.

[2ndF] [$\bar{x}$] : Used to obtain the mean value of data x entered in single- or two-variable statistical calculations.

[2ndF] [Sx] : Used to obtain the standard deviation (Sx) of the sample of data x entered in single- or two-variable statistical calculations.

[2ndF] [σx] : Used to obtain the standard deviation (σx) of the population of data x entered in single- or two-variable statistical calculations.

[2ndF] [$\bar{y}$] : Used to obtain the mean value of data y entered in two-variable statistical calculations.

[2ndF] [Sy] : Used to obtain the standard deviation (Sy) of the sample of data y entered in two-variable statistical calculations.

[2ndF] [σy] : Used to obtain the standard deviation (σy) of the population of data y entered in two-variable statistical calculations.

[2ndF] [(r)] : Used to obtain the correlation coefficient r between two variables (or data) x and y.

[2ndF] [(a)] : Used to obtain the coefficient a of linear regression equation $y = a + bx$.

[2ndF] [(b)] : Used to obtain the coefficient b of linear regression equation $y = a + bx$.

[2ndF] [(x́)] : Used to obtain the estimated value of x. (In linear regression equation $y = a + bx$, the value of x is estimated from that of y.)

[2ndF] [(ý)] : Used to obtain the estimated value of y. (In linear regression equation $y = a + bx$, the value of y is estimated from that of x.)

● Right-hand Keyboard

[SHIFT] : Shift Key
COMP, STAT, AER-I modes:
Used with [△] and [▽] keys for contrast adjustment. (See page 3.)
AER-II mode:
Used with letter keys A through Z and numeric keys 0 through 9 to enter uppercase letters and number reduced in size, respectively. (See page 126.)

[2ndF] : Second Function Key
Functions the same as the one on the left-hand keyboard.

[ZOOM] : Zoom Key
COMP mode:
Used to enlarge or reduce a graph on the graphics screen in either or both of the x- and y-axis directions at a given scale factor.

[RANGE] : Range Screen Select Key
COMP or STAT mode:
Used to call the x-axis and y-axis range screens by rotation.

[SOLVE] : Root Solving Execution Key
COMP mode:
Used to solve for one or more points of intersection (i.e., root) between the graph drawn on the screen and the x-axis of the screen.

[AUTO] : Automatic Y-Range Setting Key
COMP or STAT mode:
Used in pairs with the **DRAW** key to draw a graph based on the automatically set y-axis range key. (Pressed immediately after the expression to be graphed and before the **DRAW** key in the COMP mode and before the **DRAW** key in the STAT mode.)

[DRAW] : Drawing Execution Key
COMP or STAT mode:
Used to execute the drawing of a graph.

[GRAPH] : Graphic Command Key
COMP mode:
Used in pairs with the **DRAW** key to instruct the calculator that the expression entered must be graphed. (Pressed immediately before the expression to be graphed.)

[PLOT] : Plot Command Key
COMP mode:
Used in pairs with the **DRAW** key to display coordinates (points) on the graphics screen.

[2ndF] [LINE] : Line Drawing Key
COMP mode:
Used to connect two coordinate points on the graphics screen with a line. (Used in combination with the **DRAW** key.)

[f()=/?] : Variable Designation/Variable Input Command Key
AER-I mode:
Used to designate store memories A through Z or array variable memories A[ ] through Z[ ] as the variables of an expression or formula. For example, when you press [f()=/?] [A] [B] [f()=/?] , expression f(AB) = is entered and store memories A and B are designated as variables.

AER-II mode:
Used in a program for prompting variable data input during the program execution. (Example: a = ?)

[STO] : Store Key
Used to store a number in each of the 26 store memories A through Z by pressing this key followed by one of the **A** through **Z** keys. When these keys (for example, **STO A**) are pressed after a number (or a calculation result), the number is stored in store memory A by clearing the contents previously stored in the memory.

[RCL] : Recall Key
Used to access the contents of the designated store memory. To access each of the 26 store memories A

through Z, depress one of the **A** through **Z** keys following the **RCL** key.
(Example: **RCL B**)

[2ndF] [G(HI)] : Histogram Designation Key
STAT mode:
Used to designate a histogram (bar graph) as the type of graph to be output on the graphics screen.

[2ndF] [G(BL)] : Broken-Line Graph Designation Key
STAT mode:
Used to designate a broken-line frequency graph as the type of graph to be output on the graphics screen.

[2ndF] [G(CF)] : Cumulative Frequency Graph Designation Key
STAT mode:
Used to designate a cumulative frequency graph as the type of graph to be output on the graphics screen.

[2ndF] [G(ND)] : Normal Distribution Graph Designation Key
STAT mode:
Used to designate a normal distribution graph as the type of graph to be output on the graphics screen.

[2ndF] [G(SD)] : Scatter Diagram Designation Key
STAT mode:
Used to designate a scattter diagram as the type of graph to be output on the graphics screen.

[2ndF] [G(LR)] : Linear Regression Designation Key
STAT mode:
Used to designate linear regression as the type of graph to be output on the graphics screen.

[MAT] : Matrix Designation Key
MATRIX submode:
Used to define the name of a matrix.
(Example: **MAT A**, **MAT B**)

[2ndF] [DET] : Determinant Designation Key
MATRIX submode:
Used to define the name of a determinant.
(Example: **DET MAT A**)

[2ndF] [TRANS] : Transposed Matrix Designation Key
MATRIX submode:
Used to define the name of a transposed matrix.
(Example: **TRANS MAT A**)

[A] ~ [Z] : Memory Designation/Alphabetic Entry Keys
When one of the **A** through **Z** keys is pressed following the **STO** or **RCL** key, the corresponding store memory is designated.

AER-I mode:
Used to enter uppercase letters (A to Z).
AER-II mode:
Used to enter lowercase letters (a to z) as variables.

[SHIFT] [A] ~ [SHIFT] [Z]
AER-II mode:
Used to enter uppercase letters (A to Z).

[␣] : Space Key
AER-I or AER-II mode:
Used to enter spaces (␣) to separate two or more expressions or formulas in a program to be stored. If two keys are separated by a space, the expression immediately after the space is executed without displaying the result of the expression immediately before the space.

[,] : Comma Key
AER-I or AER-II mode: Used to enter commas to separate two or more expressions or formulas in a program to be stored. If two expressions are separated by a comma, the result of the expression immediately before the comma will be displayed before proceeding to the following one.
MATRIX mode:
Used to enter a comma to define the size of a two-dimensional array variable.
COMP or STAT mode:
Used to enter a comma to separate x- and y-coordinate values or range parameters.

[2ndF] [DIM] : Dimension Definition Key
MATRIX submode:
Used to define the dimension of an array for matrix elements.

2ndF [ ]
2ndF]] : Bracket Keys
MATRIX submode:
Used to define the size of a one- or two-dimensional array.
Example: A[3], A[3,3]

2ndF SYMBOL : Symbol Menu Screen Access Key
AER-II mode:
Used to call the special character menu screen for selection of special characters and symbols.

2ndF MASK : Masking Key
STAT mode:
Used to exclude certain statistical data stored in memory from being used in a statistical calculation.

2ndF SUB: : Subroutine Key
AER-I or AER-II mode:
Used for writing a subroutine.

2ndF ♪ : Key Click Mode Designation Key
Used to set the key click mode for both the right- and left-hand keyboard. When the calculator is set in this mode, symbol " ♪ " appears at the bottom part of the display. Pressing these keys a second time resets the key click mode.

2ndF PROTECT : Write Protect Key
MATRIX submode:
Used to protect data stored in an array variable memory from being erased by input of another data.

Compare Keys
AER-I or AER-II mode:

2ndF > : Used to determine if the magnitude of the left side of an expression is greater than that of its right side.

2ndF >= : Used to determine if the magnitude of the left side of an expression is equal to or greater than that of its right side.

2ndF ≠ : Used to determine if the left side of an expression is not equal to its right side.

[2ndF] [◣] : End Command Key
AER-I or AER-II mode:
Used to terminate program execution. (These keys are used as the End command of an algebraic expression.)

Conditional Jump Destination keys
AER-I or AER-II mode:

[2ndF] [■Y➡[]] : Used to specify the destination of a jump required if the result of conditional expression judgment is "Yes".

[2ndF] [■N➡[]] : Used to specify the destination of a jump required if the result of conditional expression judgment is "No".

Looping Keys
AER-I or AER-II mode:

[2ndF] [↰] : Used to specify the destination of a jump caused by the " ↳ " command.

[2ndF] [↳] : Used to cause program execution to jump to the point where the " ↰ " command is located.

[2ndF] [FRAC] : Fraction Key
Used to determine and display the fraction part of a number.

[2ndF] [INT] : Integer Key
Used to determine and display the integer part of a number.

[2ndF] [ABS] : Absolute Value Key
Used to determine and display the absolute value of a number.

[2ndF] [OPTION] : Option Menu Screen Access Key
Used to call the option menu screen for selection of the printer, cassette, or interface cable-related optional function.

Appendix B
Accuracy of Calculation

• Entries, and four basic arithmetic operation, 1st, 2nd operands, and calculation results:
$\pm 1 \times 10^{-99}$ to $\pm 9.999999999 \times 10^{99}$ and 0

NOTE: When the absolute value of a numeric entry or the result of a calculation is less than 1×10^{-99}, this calculator regards the value as 0 (zero) for calculation or display.

• Scientific and special functions:

Functions	Dynamic range
SINx COSx TANx	DEG: $\lvert x \rvert < 1 \times 10^{10}$ RAD: $\lvert x \rvert < \frac{\pi}{180} \times 10^{10}$ GRAD : $\lvert x \rvert < \frac{10}{9} \times 10^{10}$ With TAN x, however, an error occurs in the following cases: DEG: $\lvert x \rvert = 90(2n-1)$ RAD: $\lvert x \rvert = \frac{\pi}{2}(2n-1)$ GRAD: $\lvert x \rvert = 100(2n-1)$ (n=integer)
$\text{SIN}^{-1}x$ $\text{COS}^{-1}x$	$-1 \leqq x \leqq 1$
$\text{TAN}^{-1}x$	$\lvert x \rvert < 1 \times 10^{100}$
LNx LOGx	$1 \times 10^{-99} \leqq x < 1 \times 10^{100}$
e^x	$-1 \times 10^{100} < x < 230.2585093$

10^x	$-1\times10^{100}<x<100$
Y^x	• $y>0$ $-1\times10^{100}<x\,\mathrm{LOG}\,y<100$ • $y=0$ $0<x<1\times10^{100}$ • $y<0$ where x: integer or $1/x$: odd number($x\neq0$) $-1\times10^{100}<x\,\mathrm{LOG}\,\lvert y\rvert<100$
$\sqrt[x]{y}$	• $y>0$ $-1\times10^{100}<\frac{1}{x}\,\mathrm{LOG}\,y<100\quad(x\neq0)$ • $y=0$ $0<x<1\times10^{100}$ • $y<0$ where x: odd number or $1/x$: integer ($x\neq0$) $-1\times10^{100}<\frac{1}{x}\,\mathrm{LOG}\,\lvert y\rvert<100$
SINHx COSHx TANHx	$-230.2585093<x<230.2585093$
$\mathrm{SINH}^{-1}x$	$\lvert x\rvert<1\times10^{50}$
$\mathrm{COSH}^{-1}x$	$1\leqq x<1\times10^{50}$
$\mathrm{TANH}^{-1}x$	$\lvert x\rvert<1$
$\sqrt[3]{x}$	$\lvert x\rvert<1\times10^{100}$
$\sqrt{x}$	$0\leqq x<1\times10^{100}$

x^2	$\lvert x \rvert < 1 \times 10^{50}$
x^{-1}	$\lvert x \rvert < 1 \times 10^{100}$ $(x \neq 0)$
n!	$0 \leqq n \leqq 69$ (n: integer)
xCy xPy	$0 \leqq y \leqq x \leqq 69$ (x,y: integer)
Conversions →DEC →BIN →OCT →HEX	Converted result: DEC: $\lvert x \rvert \leqq 9999999999$ BIN: 1000000000000000 (16 digits) $\leqq x \leqq$ 1111111111111111 . $0 \leqq x \leqq$ 0111111111111111 OCT: 4000000000 $\leqq x \leqq$ 7777777777 . $0 \leqq x \leqq$ 3777777777 HEX: FDABF41C01 $\leqq x \leqq$ FFFFFFFFFF . $0 \leqq x \leqq$ 2540BE3FF
Binary/octal/hexadecimal number calculations NOT	BIN: 1000000000000000 $\leqq x \leqq$ 1111111111111111 . $0 \leqq x \leqq$ 0111111111111111 OCT: 4000000000 $\leqq x \leqq$ 7777777777 . $0 \leqq x \leqq$ 3777777777 HEX: FDABF41C01 $\leqq x \leqq$ FFFFFFFFFF . $0 \leqq x \leqq$ 2540BE3FE
NEG	BIN: 1000000000000001 $\leqq x \leqq$ 1111111111111111 $0 \leqq x \leqq$ 0111111111111111 OCT: 4000000001 $\leqq x \leqq$ 7777777777 $0 \leqq x \leqq$ 3777777777 HEX: FDABF41C01 $\leqq x \leqq$ FFFFFFFFFF . $0 \leqq x \leqq$ 2540BE3FF

Other binary/ octal/hexa- decimal num- ber calculations	The ranges for entries and calculation results in each mode are the same as the above conversions
→POL	$\|x\| < 1 \times 10^{50}$ $\quad \|y\| < 1 \times 10^{50}$ $x^2+y^2 < 1 \times 10^{100}$ $\left\|\frac{y}{x}\right\| < 1 \times 10^{100}$
→REC	$0 \leqq r < 1 \times 10^{100}$ Same range as tigonometric functions apply to the angle
→D.MS →DEG	$\|x\| < 1 \times 10^{100}$
DATA CD	$\|x\| < 1 \times 10^{50}$ $\|y\| < 1 \times 10^{50}$ $\|\Sigma x\| < 1 \times 10^{100}$ $\Sigma x^2 < 1 \times 10^{100}$ $\|\Sigma y\| < 1 \times 10^{100}$ $\Sigma y^2 < 1 \times 10^{100}$ $\|\Sigma xy\| < 1 \times 10^{100}$ $\|n\| < 1 \times 10^{100}$
$\bar{x}$	$n \neq 0$
Sx	$n \neq 0, 1$ $\|\Sigma x\| < 1 \times 10^{50}$ $0 \leqq \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n-1} < 1 \times 10^{100}$
σx	$n \neq 0$ $\|\Sigma x\| < 1 \times 10^{50}$ $0 \leqq \frac{\Sigma x^2 - \frac{(\Sigma x)^2}{n}}{n} < 1 \times 10^{100}$

$\bar{y}$ Sy σy	Same as $\bar{x}$., Sx, σx
r	$n \neq 0$ $\lvert \Sigma x \rvert < 1 \times 10^{50}$ $\lvert \Sigma y \rvert < 1 \times 10^{50}$ $0 < (\Sigma x^2 - \frac{(\Sigma x)^2}{n})(\Sigma y^2 - \frac{(\Sigma y)^2}{n}) < 1 \times 10^{100}$ $\lvert \Sigma xy - \frac{\Sigma x \Sigma y}{n} \rvert < 1 \times 10^{100}$ $\left\lvert \frac{\Sigma xy - \frac{\Sigma x \Sigma y}{n}}{\sqrt{(\Sigma x^2 - \frac{(\Sigma x)^2}{n})(\Sigma y^2 - \frac{(\Sigma y)^2}{n})}} \right\rvert < 1 \times 10^{100}$
b	$n \neq 0$ $\lvert \Sigma x \rvert < 1 \times 10^{50}$ $\lvert (\Sigma x)(\Sigma y) \rvert < 1 \times 10^{100}$ $0 < \lvert \Sigma x^2 - \frac{(\Sigma x)^2}{n} \rvert < 1 \times 10^{100}$ $\lvert \Sigma xy - \frac{\Sigma x \cdot \Sigma y}{n} \rvert < 1 \times 10^{100}$ $\left\lvert \frac{\Sigma xy - \frac{\Sigma x \Sigma y}{n}}{\Sigma x^2 - \frac{(\Sigma x)^2}{n}} \right\rvert < 1 \times 10^{100}$

a	Same as b, except the following: $\lvert b\bar{x} \rvert < 1 \times 10^{100}$ $\lvert \bar{y} - b\bar{x} \rvert < 1 \times 10^{100}$
y'	$\lvert bx \rvert < 1 \times 10^{100}$ $\lvert a + bx \rvert < 1 \times 10^{100}$
x'	$\lvert y - a \rvert < 1 \times 10^{100}$ $\lvert \frac{y-a}{b} \rvert < 1 \times 10^{100}$

NOTE: In the above calculation range, the calculation results or intermediate results are treated or displayed as 0 (zero) when their absolute values are less than 1×10^{-99}.

• As a rule, the error of functional calculations is less than ±1 at the lowest digit of a displayed numerical value (at the lowest digit of mantissa in the case of scientific notation system) within the above calculation range. In the calculation of SINHx and TANHx, x is a singular point when it is 0 (zero). Near this point the error is accumulated, reducing the accuracy.

Appendix C
How to Check Remaining Bytes

How To Check Remaining Bytes

To confirm the number of bytes remaining in memory, press the **2ndF** and **M.CK** keys irrespective of the Mode Selector switch position. Keep pressing the **M.CK** key following **2ndF**, and the display will show the number of bytes left in the memory (for example, 4691 bytes) as follows.

[2ndF] [M.CK]

```
PROGRAM    : 345
DIMENSION  :  84

4691 BYTES LEFT
```

← No. of bytes used for program steps

← No. of bytes used for array variable memories

← Total remaining capacity in bytes

When you store a number of programs (algebraic expressions) in memory, write a program into memory while confirming the remaining bytes from time to time through this operation. Bytes are the number of bits that a computer or programmable calculator processes as a unit. With the calculator, one byte corresponds to one program step.

How To Count Number of Program Steps

A program titled "PYTHAGORAS" and stored in memory in the programming example on page 128 is used here as an example of counting the number of steps.

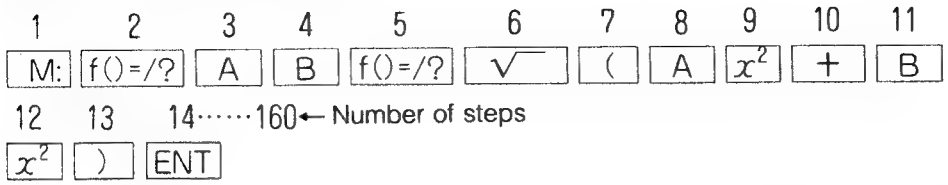
1	2	3	4	5	6	7	8	9	10	11	12	13
Ø	1	:	P	Y	T	H	A	G	O	R	A	S

14·····160← Number of steps

[ENT]

Because a title is stored in memory as shown in the above example, a memory space of 14 steps is required in this case. The total number of steps for a title consists of the number of title characters plus 4 steps.

• Main routine and subroutine



The total number of steps for entry of a main routine or subroutine consists of the number of steps entered plus 2 steps.

NOTE: 1. **ENT** and **2ndF SUB:** keys are not included in the 160 steps permitted for a program entry, but these key entries require one byte of memory.

2. If variable characters are used for an algebraic expression in the AER-II mode, the calculator counts the total number of steps by adding the number of characters used as variables and 11 steps per variable to the number of steps entered.
3. If message "ERROR 4" appears in the display while writing an algebraic expression in memory, press the **CL** key to clear the error condition. Press the **2ndF** and **M.CK** keys to check the remaining bytes and then either delete the excessive portion of the program contents previously stored in memory or enter the contents of the expression being programmed so as not to exeed the remaining bytes. (See APPENDIX D for error messages.)

Appendix D
Error Conditions and Messages

Error Conditions

If you attempt to execute an operation exceeding the calculation range of the calculator or any illegal operation, the unit will detect such operation as an error condition and indicate the pertinent error code or message, prohibiting you from subsequent operations. To clear the error condition, press the **CL** key (or the **PB** key).

If an error occurs, press the **PB** key and the location of the error will be indicated by a blinking cursor. (See Playback Function in Chapter 2.)

Error Messages

Code	Description of Error

ERROR 1 – Syntax error (e.g., 3 × ÷ 2 = , GRAPH GRAPH DRAW, AUTO ZOOM.)

ERROR 2 – Calculation error:
- Result of an operation or the value of a pending operation exceeds the calculation range of the calculator. (See APPENDIX B for the calculation range.)
- Division by zero was attempted.
- Numeric entry exceeds the input range of the function in a scientific calculation.
- An illegal operation was attempted (e.g., $\sqrt{-1}$) or a scientific calculation was attempted in the BIN, OCT, or HEX mode.
- An illegal range setting was attempted to draw a graph.

ERROR 3 – Nesting error:
- Data or function exceeds the capacity of 8-stage data buffers or 16-stage function buffers.
- More than 15 loops are used in the looping feature.
- Attempt was made to jump from one subroutine to another.
- Attempt was made to display the calculation result of an expression more than 1,000 times.

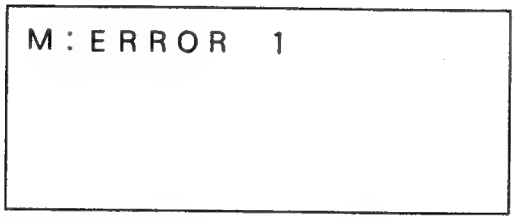
ERROR 4 – Memory error/overflow:
- Program (or expression) exceeds the memory capacity.
- An error related to memory exists.

ERROR 5 – Dimension error:
- Attempt was made to define more than two dimensions for an array.
- Attempt was made to access a write-protected array.

ERROR 6 – I/O error:
- An error related to an input/output device exists.

• If an error is found in a program (or expression) stored in the AER-I or AER-II mode and executed with the **COMP** key in the COMP mode, main ("M:") or subroutine (e.g., " 1 ") indicator where the error has occurred will appear in the display, followed by the pertinent error code.

Example:



The above display indicates that an error exists in the main routine.
To review the erroneous program line, press the **PB** key. The program line with a blinking cursor showing the location of the error will appear in the display when you keep pressing the **PB** key.

Appendix E
Priority Levels in Calculation & Pending Operations

Priority Levels

This calculator is provided with a function that judges the priority levels of individual calculations. Normally, the unit permits you to perform the key operation of a given algebraic formula as written. The following shows the priority levels of individual calculations.

(1) (−)

(2) π, recall of memory contents, recall of answer memory, random number generating function

(3) Single-term function preceded by a number
(Example: x^2, x^{-1}, n!, →DEG, →D.MS)

(4) Two-term function preceded and followed by a number
(Example: nCr, nPr, Y^x, $\sqrt[x]{\ }$, →POL, →REC)

(5) Multiplication where " × " command located just before π or a store memory or before a single-term function followed by a number has been omitted from entry.
(Example: 2π, 4A)

(6) Single-term function followed by a number
(Example: $\sqrt{\ }$, e^x, 10^x, $\sqrt[3]{\ }$, LN, LOG, SIN, COS, TAN, SIN^{-1}, COS^{-1}, TAN^{-1}, SINH, COSH, TANH, $SINH^{-1}$, $COSH^{-1}$, $TANH^{-1}$, ABS, INT, FRAC, NEG, NOT)

(7) ×, ÷

(8) +, −

(9) AND

(10) OR, XOR, XNOR

(11) =, M+, M−(2ndF M+), ⇒M, STO A to STO Z, →BIN, →OCT, →HEX, →DEC, ␣ (space), '(comma), DATA*, CD*, (x,y)*, x'*, y'*, >, >=, ≠, ↳, ↰, −Y.→[ ], −N→[ ], ◣, etc.

★ Applicable in STAT mode only.

- Parenthesized calculations have precedence to any other calculations.

- Provided that functions shown in item (6) above are successively designated in an algebraic expression, calculations are performed from the right to the left.

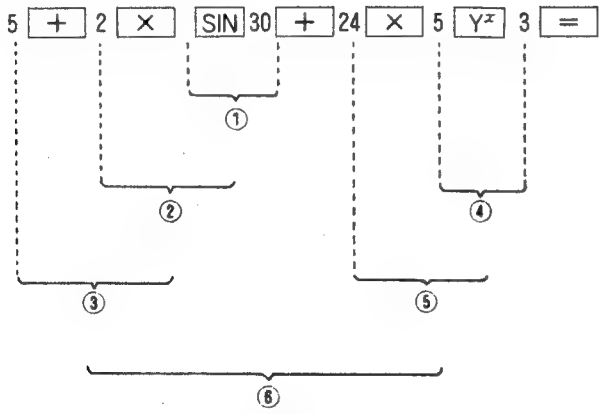
$e^x LN\sqrt{\ }120 \rightarrow e^x\ \{LN(\sqrt{\ }120)\}$

- The other functions are calculated from the left to the right.

$A^x\sqrt{\ }BY^xCY^xD \rightarrow\ \{(A^x\sqrt{\ }B)Y^xC\}\ Y^xD$

Order of calculations in a typical example:

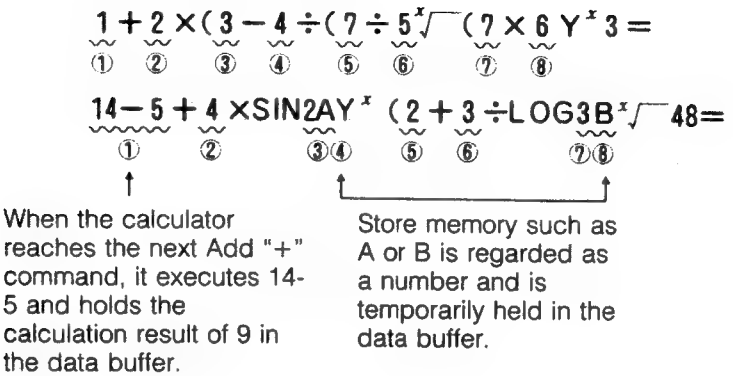
EX. $5+2\times SIN30+24\times 5^3=$



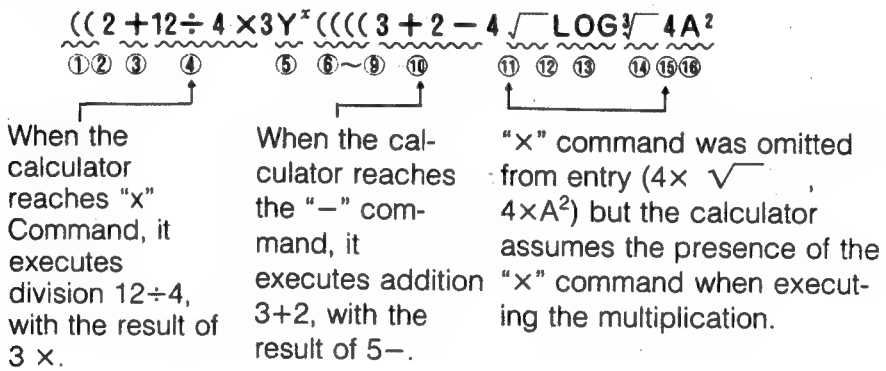
Pending Operations

When the calculator performs calculations according to the established priority levels or performs a parenthesized calculation before any other calculations, the unit must suspend or set aside the calculation commands and numbers (or values) that cannot be processed immediately. For this reason, the calculator is provided with a memory area for pending operations, consisting of a 16-stage function buffer and a 8-stage data buffer. In other words, a maximum of 16 calculation commands and a maximum of 8 numbers can be stored in the memory area. Note that an error condition occurs if this memory capacity is exceeded by these pending operations.

Example 1
Calculation with 8 pending numbers



Example 2:
Calculation with 16 calculation commands including parentheses



Appendix F
Battery Replacement

The calculator uses two lithium batteries as its main DC power supply. The calculator also uses another lithium battery for memory backup.

- When replacing either of the main and backup batteries, be sure to press the **OFF** key (on the left-hand keyboard) to turn off the power of the calculator.
- Do not replace the batteries for main DC power and memory backup at the same time, or the memory contents of the calculator may be lost.

When to Replace Batteries for Main DC Power Supply

If the indicators and numbers in the display (LCD) appear to be dim, press the **SHIFT** and [△] keys for a higher contrast. If they still appear to be dim, it is the signs of the low battery voltage, meaning that the batteries are nearing the end of their life. Replace the batteries as quickly as possible. Note that use of the calculator with the exhausted batteries may result in loss of the memory contents.

How to Replace Batteries for Main DC Power Supply

(1) Press the **OFF** key to turn off the power of the calculator.

(2) Remove the two setscrews with a phillips screwdriver from the rear of the calculator and detach the rear cover.

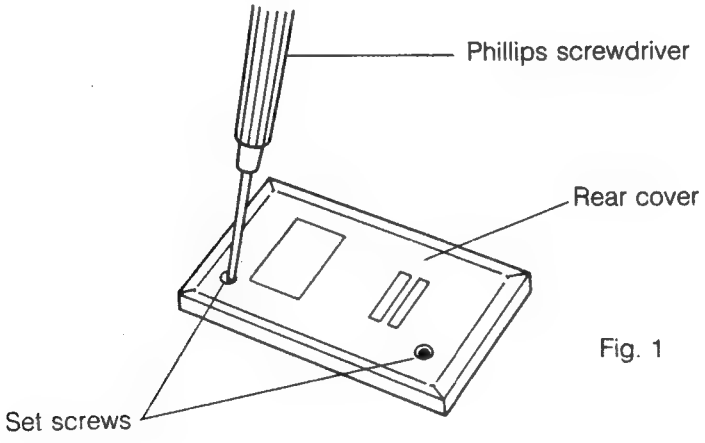


Fig. 1

(3) Unscrew the battery keep plate with a Phillips screwdriver, detach the keep plate, and remove the two old batteries from the battery compartments.

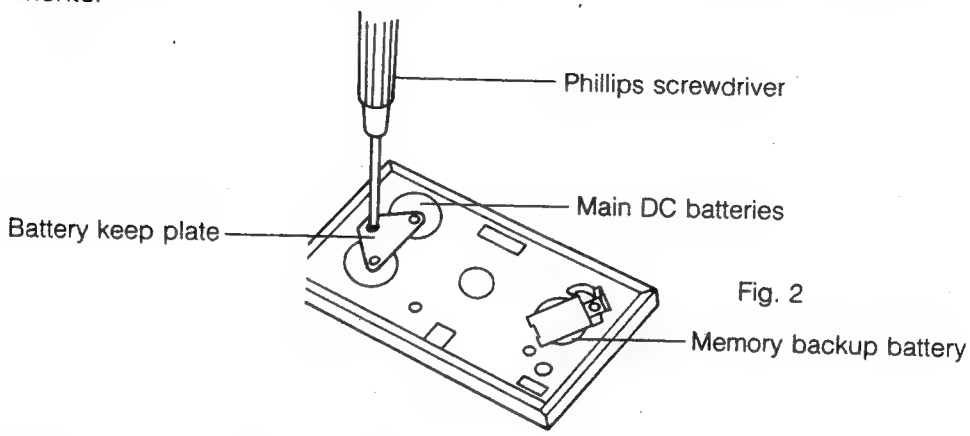


Fig. 2

(4) Insert two new batteries (CR2032 lithium batteries) in the battery compartments with attention paid to the polarity as shown in Fig. 3. Before inserting the two new batteries, wipe them clean with a dry cloth. When replacing the main DC power supply, do not unload the memory backup battery.

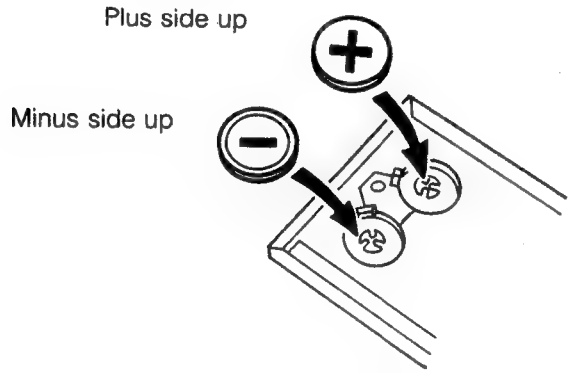


Fig 3

(5) Put the battery keep plate back to its original position and secure it with the setscrew.

(6) Hook the three claws (or projections) of the rear cover into the corresponding slots at the side of the calculator and secure the rear cover to the unit with the two setscrews while gently holding down the rear cover.

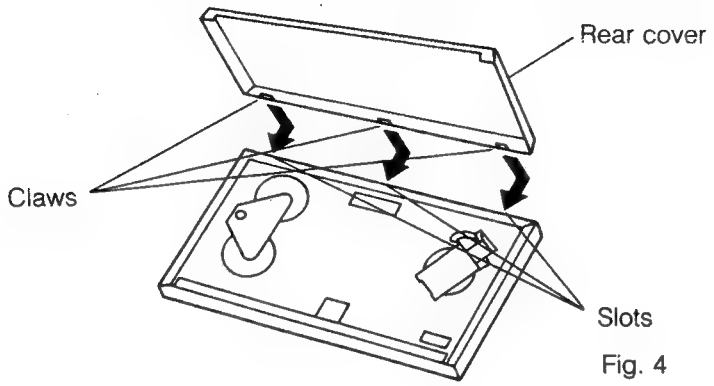
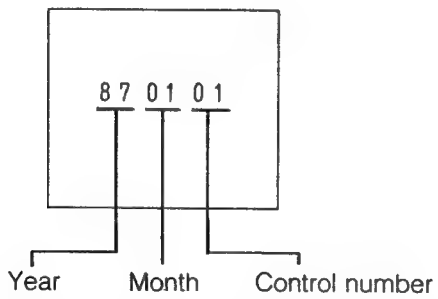


Fig. 4

(7) Slide the Mode Selector Switch to the COMP position and push the Reset switch again to confirm that "Ø." is appearing in the display. If not, unload the batteries and repeat the battery replacement procedure from the beginning.

Life of Memory Backup Battery

The memory backup battery will protect the calculator's memory contents for about 5 years at a room temperature of 20°C. The date (year and month) of battery loading is indicated on the label attached to the rear of the calculator at the time of its shipment. Refer to this date for determining the appropriate time of battery replacement.



NOTE: The service life of the battery is governed by its operating environments and may be shortened from use at extremely high or low temperatures. In the worst case, this may result in loss of data or destruction of the memory contents.

How to Replace Memory Backup Battery

Before replacing the backup battery, make sure that the batteries for the main DC power supply have not become exhausted. If exhausted, replace the main batteries first and then the backup battery, or the memory contents of the calculator may be lost.

(1) Press the **OFF** key to turn off the power of the calculator.

(2) Remove the two setscrews from the rear of the calculator and detach the rear cover as shown in Fig. 1.

(3) Unscrew the battery keep plate with a phillips screwdriver and remove it.

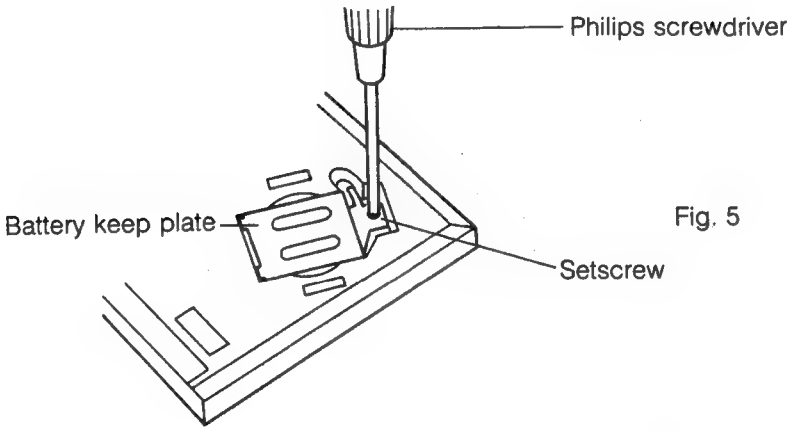


Fig. 5

(4) Remove the old battery and replace it with a new one (CR2032 lithium battery) with attention paid to the polarity as shown in Fig. 6. Before inserting the new battery, wipe it clean with a dry cloth.

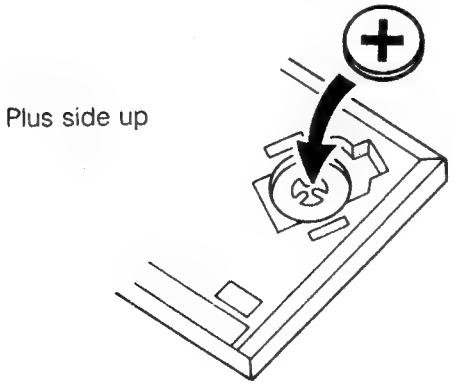


Fig. 6

(5) Secure the battery keep plate with the setscrew.

(6) Secure the rear cover to the unit as shown in Fig. 4.

Hints on Use of Batteries

1. When replacing the two main batteries, be sure to replace both batteries at the same time.
2. Avoid replacing the main batteries with one fresh and one used batteries combined.
3. Use the lithium batteries of the same type for replacement.
4. Insert the replacement batteries with attention paid to the polarity as indicated in the battery compartment (i.e., plus side up and minus side up).
5. Replace the memory backup battery every 5 years.

Cautions

- Keep the batteries out of reach of children.
- Dispose of old batteries safely. The batteries may explode if placed in a fire.
- The original batteries were installed upon shipment from the factory, so the battery life may be somewhat less than the normal 130 hours operating time.
- Remove the batteries when they become exhausted or if they are to be stored indefinitely. The batteries may leak and cause damage.

Date of Battery Replacement Label (for Memory Backup Battery)

A label is attached to the rear cover to enter the dates of battery replacement. Be sure to enter each date of replacement with a ball-point pen, pencil, or felt-tip pen so that it may be used as a guide in determining the appropriate time of subsequent replacement.

Appendix G
Specifications

Model:	EL-9000
Number of internal calculation digits:	Mantissa: 12 digits; Exponent: 2 digits
Calculation system:	As per algebraic expression (with priority judging function)
Memory:	• 26 memories A-Z (one independent accessible memory shared with store memory M and 25 store memories) • 27 variable memories A[ ] to Z[ ], ANS.(Maximum No. of memory columns: 639) • Total No. of memory calumns: 665
Display type:	Dot matrix liquid crystal display (16 columns × 4 rows for characters, 96×32 dots for graphics)
Display capacity/mode:	Mantissa: 10 digits; Exponents: 2 digits Automatic changeover between the floating decimal point display system and any of the following display systems: Fixed decimal point system (FIX) Scientific notation (SCI) Engineering notation (ENG)
Calculations:	Four basic arithmetic operations, trigonometric and inverse trigonometric functions, hyperbolic and inverse hyperbolic functions, conversion of angles, reciprocals, square root and cubic root, square and power, logarithmic and exponential functions, Xth root of Y ($\sqrt[x]{y}$), factorial, permutations, combinations, conversions of coordinates, memory calculations, matrix operations, statistical calculations, binary/octal/hexadecimal number calculations, logical operations, absolute value, integer/fraction part delete, modify, answer memory, random number generation etc.
Memory check function:	Remaining capacity is displayed in bytes
AER functions:	Variable designation, expression separation, end of command, conditional judgment, looping, subroutine, program title search, etc.

Graphic functions:	Drawing graphs of intrinsic functions and n-th degree equations and statistical graphs (histogram, broken-line, cumulative frequency graph, normal distribution graph, scatter diagram, linear regression) Tracing, plotting, line drawing, enlarging/reducing, scrolling, and root solving functions
General calculation capacity:	160 steps
Algebraic expression reserve capacity:	5120 steps
Editing functions:	Cursor control, insertion, deletion, and playback
Components:	LSI, etc.
Power supply:	6V⎓(DC) main: Lithium battery (CR2032)×2 3V⎓(DC) backup: Lithium battery (CR2032)×1
Power consumption:	0.015W
Operating time:	Approx. 130 hours continuous (at 20°C (68°F) with 5555555555555555 displayed in 2 rows)
Memory backup:	Approx. 5 years
Operating temperature:	0° to 40°C (32°to 104°F)
Dimensions:	82 (W)×138 (D)×14 (H) mm (with the cover closed) 170 (W)×138 (D)×11.5 (H) mm (with the cover open) 3−7/32″ (W)×5−7/16″ (D)×9/16″ (H) (with the cover closed) 6−11/16″ (W)×5−7/16″ (D)×15/32″ (H) (with the cover open)
Weight:	150 g (0.33 lb) (including batteries)
Accessories:	3 built-in lithium batteries and Operation Manual

Appendix H
Scientific & Calculator Functions

Scientific Functions

Trigonometric, Inverse trigonometric	sin, cos, tan, $\sin^{-1}$, $\cos^{-1}$, $\tan^{-1}$	6
Hyperbolic, Inverse hyperbolic	sinh, cosh, tanh, $\sinh^{-1}$, $\cosh^{-1}$, $\tanh^{-1}$	6
Exponential, Logarithmic	e^x, 10^x, ln, log	4
Power, Power root	y^x, $\sqrt[x]{y}$	2
Square, Square root, Cubic root, Reciprocal	x^2, $\sqrt{\ }$, $\sqrt[3]{\ }$, $1/x$	4
Angle mode designation	DEG, RAD, GRAD	3
Angular unit conversion	→D·MS, →DEG	2
Coordinate Conversion	→POL, →REC	2
Statistical functions Single-variable Two-variable Linear regression Prediction Others	 n, Σx, Σx^2, $\bar{x}$, σx, sx Σy, Σy^2, Σxy, $\bar{y}$, σy, sy r, a, b x', y' DATA entry (DATA), correction (CD), MASK, PROTECT, DT.STO	 6 6 3 2 5
Factorial, Permutations, Combinations	n!, nPr, nCr	3
Absolute Value, Integer, Fraction	ABS, INT, FRAC	3
Number system conversion	DEC←→BIN, DEC←→OCT, DEC←→HEX, BIN←→OCT, BIN←→HEX, OCT←→HEX	12
Binary, octal, decimal, hexadecimal number operations, Complement	Binary, octal, decimal, hexadecimal number operations, (NEG)	4
Logical Operations	NOT, AND, OR, XOR, XNOR	5
Matrix operations	Four basic operations, determinant value, inverse matrix, transposition, squaring of matrix, sign change	13
Display mode	FIX, SCI, ENG, TAB	4
Modify (Rounding)	MDF	1
Data (pi, exponent) entry	π, Exp	2
Parentheses (open/close), Pending operations	(,)	3
Random number generation	RND	1

Graphics functions		
Graphics commands	GRAPH, AUTO	2
Plot, Line drawing	PLOT, LINE	2
Trace, coordinate value display	◁, ▷, X↔Y	3
Statistical graphs	Histogram, broken-line graph,etc.	6
Enlargement and reduction of graphic display	ZOOM (enlargement, reduction)	2
x- /y-axis range setting	RANGE	1
Graph drawing execution	DRAW	1
Root solving	SOLVE	1
Screen selection	T▶G▶D	1
Array definition	DIM	1
Total:		122

Calculation Functions

Clear, Edit	CL, CA, ◁, ▷, INS, DEL, PB, △, ▽, G.CL	10
Four basic operations	+, −, ×, ÷	4
Independently accessible memory	RM, M+, ⇄M, 2ndF M+ (M−)	4
Store memories	A, B, C, ... L, N ~ Z	25
Last answer recall	ANS	1
Negative number entry	(−)	1
Total:		45

Programming Functions

Variable designation	f( )=, =?, flexible variable (AER- II mode)	3
Calculation result display, Formula separation	Comma, Space, ◣	3
Conditional expression judgment	>, >=, ≠	3
Branching	–Y→[ ], –N→[ ]	2
Looping	↳, ↰	1
Addressing	Up to 99 expressions (program titles) can be programmed.	1
Program title search, Data title search	PRO (TITLE), 2ndF PRO (TITLE), DATA (TITLE), 2ndF DATA (TITLE)	4
Subroutine	SUB:	1
Program execution	COMP	1
Input/output from/to peripherals	COPY DISP (4 sizes), PRINT, SAVE, SAVE ALL, LOAD	8
Total:		27

194 functions
122 scientific 45 calculator 27 programming